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COMING EVENTS

Apr. 21-22, AIME Pacific Southwest Regional Metals and Minerals Conference, Ambassador Hotel, Los Angeles.

Apr. 21-23, National Western Mining and Energy Meeting, Denver-Hilton Hotel, Denver. (Meeting date changed.)

Apr. 25-27, CIM Annual Meeting, Royal York Hotel, Toronto.

Apr. 28-30, AIME Pacific Northwest Regional Conference, Sheraton Hotel, Portland, Ore.

May 6-8, AIME Uranium Section, annual symposium, Moab, Utah.

May 9-11, American Mining Congress, Coal Convention, Pittsburgh.

May 9-13, 2nd Southwestern Metal Exposition and Congress, ASM, State Fair Park, Dallas.

May 16-20, International Conference on Strata Control, sponsored by Charbonnages de France, Paris, France

May 19-20, Lake Superior Mines Safety Council, 36th annual conference, Hotel Duluth, Duluth.

June 1-3, Appalachian Underground Corrosion Short Course, West Virginia University, Morgantown, W. Va.

June 5-10, ASME semi-annual meeting, Statler Hilton Hotel, Dallas.

June 10-11, AIME Central Appalachian Section, spring meeting, Martha Washington Inn, Abingdon, Va.

June 10-11, Wyoming Mining Assn., Jackson Lake Lodge, Wyo.

June 18-19, AIME Colorado Plateau Section, technical meeting, dinner-dance, Ouray, Colo.

July 11-18, 2nd World Conference on Earthquake Engineering, organized by Science Council of Japan in cooperation with Japan Soc. of Civil Engineers, Architectural Inst. of Japan, Seismological Soc. of Japan; Tokyo and Kyoto, Japan.

Aug. 6-7, AIME Colorado Plateau Section, annual jeep trip.

Aug. 15-25, International Geological Congress, Copenhagen, Denmark; for information, write Mineralogical-Geological Museum, University of Copenhagen, Oster Voldgade 7, Copenhagen K, Denmark.

Sept. 8-9, SME Coal Div. and AIME St. Louis Section, joint meeting, Chase-Park Plaza Hotels, St. Louis.

Sept. 12-18, International Mining Congress, sponsored by the Hungarian Mining & Metallurgical Soc., Budapest, Hungary.

Sept. 12-16, Pan American Congress on Engineering Education, Buenos Aires, Argentina.

Sept. 19-23, 7th Convention of Pan American Assn. of Engineering Socs., Buenos Aires, Argentina.

Oct. 5-7, AIME Rocky Mountain Minerals Conference, Utah Section host, Newhouse Hotel, Salt Lake City.

Oct. 6-8, 9th National Clay Conference, Purdue University, Lafayette, Ind.

Oct. 10-13, American Mining Congress, Mining Show (metal mining-industrial minerals convention, exposition), Convention Center, Las Vegas, Nev.

Oct. 17-19, Drilling and Mining Symposium, sponsored by Colorado School of Mines, Pennsylvania State University, and University of Minnesota, Colorado School of Mines, Golden, Colo.

Oct. 24-25, AIME-ASME Joint Solid Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.

Nov. 4, AIME Pittsburgh Section, Off-the-Record meeting, Penn-Sheraton Hotel, Pittsburgh.

Nov. 7-10, Soc. of Exploration Geophysicists, annual international meeting, Galveston, Texas.

Nov. 18, American Mining Congress, coal division conference, Penn-Sheraton Hotel, Pittsburgh.

Dec. 3, AIME Colorado Plateau Section, technical meeting, election of officers, WAAIME dinner-dance, Grand Junction, Colo.

Feb. 26-Mar. 2, 1961, AIME Annual Meeting, Chase and Park-Plaza Hotels, St. Louis.

Apr. 12-14, International Symposium on Agglomeration, sponsored by SME, SPE, and TMS of AIME, Hotel Sheraton, Philadelphia.

Sept. 17-20, Commemoration of the 50th Anniversary of Froth Flotation in the U.S.A., sponsored by AIME: Society of Mining Engineers' Mineral Beneficiation Division, Cosmopolitan Hotel, Denver.

MINING engineering

VOL. 12 NO. 4 APRIL 1960

COVER MINING ENGINEERING *is devoting this issue to a complete report (beginning on page 339) on the development and operation of El Salvador mine and plant run by the Andes Copper Mining Co., subsidiary of The Anaconda Co. Artist Herb McClure features the Inca adit in his cover presentation.*

EL SALVADOR DEVELOPMENT & OPERATION

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Index to material in MINING ENGINEERING during 1959 will be bound into the June 1960 issue. For why the Index is late, see "Drift," page 337.

MINING ENGINEERING staff, Society of Mining Engineers, and AIME Officers are listed on the *Drift* page.

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PERSONNEL

THESE items are listings of the Engineering Societies Personnel Service Inc. This Service, which cooperates with the national societies of Chemical; Civil; Electrical; Mechanical; Mining, Metallurgical, Petroleum Engineers, is available to all engineers, members and nonmembers, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5 pct of the first year's salary of a nonmember, or 4 pct if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number. When making application for a position, include 8¢ in stamps for forwarding application to the employer and for returning when possible. A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for nonmembers, payable in advance. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.**

In addition to the listings below, ESPS maintains a more complete file of general engineering positions and men available. Contract nearest ESPS office, listed above.

MEN AVAILABLE

Mining Engineer, B.S., age 30. Eighteen months construction, surveying, and drafting; two years pipeline construction; four years sales engineering to mines and contractors. Registered professional engineer. Location, immaterial. M-531.

Geologist-Petrographer, M.S. in mineralogy. Knowledge of spectrographic analysis and experience in petrography and geology. Desires position as petrographer and mineralogist. M-524.

Assistant Mine Superintendent or Lesser Position, B.S. in mining, age 40. Engineering, six years; milling, two years; production, four years. Prefer Canada, U.S., or Americas. M-525.

Quarrying or Exploration Geology Position, B.S. in geological engineering. One year as geologist investigating dam foundations using core drill; seven months sales engineer selling pumps and conveying equipment. Desire western U.S., preferably Arizona. M-526.

Geologist, B.S. (honors), M.A., age 41. Engineering geology, 11 years, as exploration supervisor foundation and materials for engineering structures. Mineral exploration and evaluation, six years. Location, immaterial. M-527.

Junior Geologist (mining or metals exploration preferred), M.S. in geology. One summer work with USGS as rodman, another summer work with Army Corps of Engineers as soils laboratory assistant. Prefer U.S. or Canada but will accept foreign assignment. M-528.

Geologist, M.A., age 28. Experienced in base metal mining and exploration in northwest, also Quebec and Appalachians. Seeks position dealing with exploration and development of mineral resources. Location, immaterial. M-529.

Mining Engineer in Planning or Control, graduate, age 29. Summer work in coal, salt, metal, lignite mining; ten months experience in mine layout design; ten months experience field surveying and claim work. M-1063-Chicago.

Ground Water Engineering Geologist, B.A. Ten years administrative and field experience, heavy emphasis all phases of ground water development programs including field explorations, evaluations, seismic and resistivity surveys, design. Experienced all types of drilling methods. Desire responsible position with private, industrial, or consulting organization. Location desired, continental U.S. M-530.

Mine Manager or Superintendent, age 47. Twenty-one years experience in mining, location, examination, supervision of development and operation, assist in sales, preparing schedules on placer and surface mines; iron ore, coal, and gold. Three years preparing schedules of manpower and material for shipyard. Salary, open. Any location. Home, San Francisco East Bay. Se-1040.

Manager or Executive Assistant, mining engineer, age 49. Petroleum engineer with supervisory capacity to direct, manage, or assist in management overseas drilling or exploratory activity of independent producer/contractor or oil company, or similar duties, domestic drilling/producing operations. Speak Spanish and German. Ten years overseas experience. Salary desired, $9600 domestic; $12,000 foreign. Prefer overseas. Home, California. Se-1021.

Geologist or Junior Mining Engineer, geological engineering, age 23. Summer experience in mining and geology, including geological, survey, quality analysis, sampling, personnel relations, etc. Four field courses in geology, plans survey, field geology, mining geology, geochemistry. Military completed. $5700. Any location. Home, California. Se-1007

Mine-Mill Manager, E.M. in mining and metallurgy, age 40. Thirteen years experience economic evaluation, organizing exploration programs, staff and operate properties, budgets, financing, labor negotiations on fluorspar, uranium, manganese, Pb-Zn mining and milling. Two years in charge of sales, estimating, mine-mill design, consulting for engineer-constructor. $12,000. Prefer California or U.S. Home, California. Se-922.

Manager, E.M. in mining, age 68. Professional engineer license; 38 years experience supervising design and layout on mining beneficiation, iron ore, and cement plants; also superintendent and consultant on mining. $12,000. Prefer San Francisco or West Coast. Home, San Francisco peninsula. Se-984.

Mine Manager, mining engineer, age 45. Nineteen years experience managing, special studies, charge of properties, calculations, reserves on gold, silver, copper, zinc, pyrites mines and mills. Also three years in charge of geological work on bauxite deposits. $9600. Prefer warm climate. Home, California. Se-942.

Mine Management, mining engineer, age 62. Experience: 24 years mine in management; 16 years all other phases mine operations. Specialist in practical mine economics; diagnosing ills and prescribing treatment for noneconomic operations. $12,000. Prefer western U.S. Home, Arizona. Se-864.

POSITIONS OPEN

Mining Engineers. a) *Mine superintendent,* graduate with minimum of five years experience for underground 10,000 tpd metal mine. Salary, $12,000 year. b) *Mining Engineers,* recent graduates will be considered for survey, mapping, etc. at metal mine. Salary, to $6000 year. Location, South. W8520.

Junior Mining Engineer, recent graduate, young, for ventilation control, underground mapping and surveying. Experience in this field preferred but not necessary. Salary, open. California. Sj-4995.

Senior Geologist, graduate and 15 years experience in metallic mineral exploration. Able to efficiently organize and manage all phases of exploration program including geophysical surveys. For operation consisting of 3000 tpd copper and pyrites underground mine, concentrator, and shipping facilities. Long term exploration program has been started and waste stripping for open cut mining operation will start early this year. $15,000 to $20,000. Mediterranean. Sj-4989

Mining Engineer, graduate mining engineer or civil engineer with experience in mining. Two to three years experience in open pit, preferably copper mining, thorough knowledge of surveying, mapping, estimating, able to write clear and concise reports, some knowledge of other aspects of mining operation, i.e., milling, construction, costs. Start-

(Continued on page 298)

MINERAL ENGINEER-GEOLOGIST, 10 years diverse experience in mineral and petroleum, hard rock and placer mining operations, primary and secondary metallurgy. Experience in U.S., Canada, Australasia, South America; presently with oil major in North Africa. Age 34, married, AIME, AAPG; working knowledge French, Spanish, Italian, and Arabic. Applicant seeks field and/or administrative post with foreign or domestic mining, petroleum, or consulting organization or company with related interests (marketing or representation). Available June or earlier. Write: Box 60ME3, MINING ENGINEERING, 29 W. 39th St., New York 18, N.Y.

"TROUBLE SHOOTER"

The Florida Department of our Mining Division, located at Nichols, has an opening for an engineer with a degree in Mining Engineering or Ore Dressing for a combination field and laboratory "Trouble Shooting" assignment in the wet processing phosphate rock operation.
No experience is required although familiarization with the industry would be preferable. Please send resume giving full details of education and training to:

Personnel Department
Virginia-Carolina Chemical Corp.
401 East Main Street
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MILL MANAGER

Medium size company with capital to support continued expansion is seeking a young mill manager with uranium milling experience. Man selected must have potential for increased responsibilities as company expands. Company is now operating in the Rocky Mountain Area. Reply to: Box 60ME1, 29 West 39th Street, New York 18, New York.

GEOPHYSICIST

Recent graduate required for supervision of geophysical surveys and for laboratory studies in cooperation with exploration program in the U.S. and Canada. Would be based in Research Department at Palmerton, Pa. Some field experience and geological training desirable.

Reply direct to:

Research Department
The New Jersey Zinc Co.
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ASSOCIATE PROFESSORSHIP, Mining Engineering. To teach courses and conduct research in the following divisions:
1. Rock mechanics or geomechanics.
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Professor Edward A. Dines
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University of Pittsburgh
Pittsburgh, Pennsylvania

Mining Engineer to head engineering department of a group of mines of progressive Central Pennsylvania mining company. For appointment, state qualifications and experience, writing: Box 60ME2, MINING ENGINEERING, 29 W. 39th St., New York 18, N.Y.

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"Before buying two International® 65 Payhauler trucks, we had demonstrations by several large haulers," reports Edgar N. Putnam, for New Hope Crushed Stone & Lime Co.

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A COMPLETE POWER PACKAGE

LETTERS

Zinc Production

Dear Editor:

I enjoyed reviewing the Annual Review number, all except one statement on p. 140. In regard to zinc the statement is made, "Domestic mine production was at a high rate in the first half of the year . . ." I know that the statement is a direct quotation from a preliminary report of the Bureau of Mines, but it ignores facts completely.

A "high rate" compared to what? Not to the first half of 1958, for in that year of abnormally low mine zinc production 220,445 tons were produced compared with 218,853 tons in the "high rate" (?) period of 1959. The first half of 1957 saw 284,103 tons produced. The last half of 1958 saw a production level of 191,560 tons. The total 1958 production was the lowest since the deepest of the depression years.

To honestly make the statement that domestic mine production of zinc in the first half of 1959 was at a higher rate, one would have to carefully explain that it was higher only than the last half of 1958, which period saw the lowest nonstrike period production rate since the deepest of the depression years.

The uninformed read such false and misleading statements and decide all is well. It's discouraging to read such misleading information in a mining magazine.

Yours very truly,

Miles P. Romney, Manager
Utah Mining Assn.

PERSONNEL

Continued from page 296

ing salary for well qualified man, $7200. Arizona. Sj-4987.

Sales Assistant, mining engineer or mechanical engineer, recent graduate or one or two years working experience. Aptitude, qualifications, desire to assist in small office as trainee in sale or separation equipment for ore milling, assist in preparation of proposals, pricing, correspondence, client contact to promote use and sale. For manufacturer's representative. Salary commensurate. San Francisco headquarters. Sj-4974.

Geologist, advanced degree preferred, petrographic ability essential. For field and office work with established mine exploration company in nonferrous metal mining. Headquarters, Northern California, field work generally in Western U.S. Apply by letter with transcript of grades and expected salary. Sj-4962.

Assistant Mine Manager, graduate mining engineer, with knowledge of geology. Married, preferably under 35, at least four years experience working in open pit or underground, to assist general manager and direct in mining operation and also be responsible for marketing and shipping, for large open pit and underground fluorspar mine in Mexico. Preferably able to speak Spanish. Start $7200, to be raised after proving himself. Discuss payment of placement fee with employer. Sj-4939.

Sale Engineer, graduate mining engineer or mechanical engineer. Young. Experienced in both surface and underground drilling for a good understanding of hydraulic and compressed air. Able to analyze special applications and able to recommend proper equipment. Also able to conduct distributor's sales meetings and meet top management personnel. Free to travel. For a national manufacturer. Salary commensurate. Sj-4936.

Mining exploration, mining engineer, with geology background, under 35. Five to ten years mining experience preferably iron or open pit or some underground. Capable of conducting new property exploration work including design, drilling, assembling samples for lab tests, and prepare reports. Should be capable of advancement to responsible position and operation after exploratory work. About $8000. For a mining company. Western U.S. Sj-4933.

Mining Engineer, graduate, under 30. Experience in open pit operation; some underground mining helpful, experience with gravity and flotation mills. Job training for supervisor level. $6000 to $6600. Midwest. Sj-4931.

Design Engineers, mining, civil, or mechanical engineering degree preferred, with previous industrial design experience in connection with mining, ore dressing, and smelting or refining plants, equipment, and facilities. $7,200 to $10,200. Western U.S. Sj-4928-R(a).

Estimator, mining engineering, metallurgical engineering, or mechanical engineering. Broad experience heavy industrial construction and engineering estimates, preferably mining and mineral industry. Qualified to make cost estimates on project, budgetary and appropriation estimates, supervise small group. Salary and benefits. Western U.S. Sj-4928-R(c).

Process and Sell, understudy for plant or management in nonmetallic minerals company, mining or buying nonmetals for process and selling in Central California. Start in mining, advance to production, then commercial aspects. $5400 start. San Francisco. Sj-4904-R.

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"TELLEVEL"®
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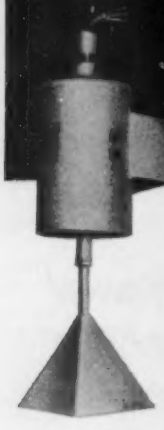

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WRITE FOR BULLETIN 159

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BOOKS

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Dana's Manual of Mineralogy, revised by Cornelius S. Hurlbut, Jr., 17th edition, *John Wiley & Sons Inc.*, 609 pp., $11.50, 1959.—The present edition of this standard text places a greater emphasis on the crystal-chemical approach as a means of relating the fundamental structural and chemical properties of minerals. The topics included are crystallography; physical, chemical, and descriptive mineralogy; occurrence and association of minerals; mineral uses, and determinative mineralogy. The material on crystallography has been expanded to include the stereographic projection, the thirty two crystal classes, the calculation of axial ratios, and X-ray crystallography. • • •

Directory of Geoscience Departments in the Colleges and Universities of the United States and Canada, *American Geological Institute*, 2101 Constitution Ave., Washington 25, D.C., 126 pp., $2.00, 1960.—This directory lists colleges and universities offering undergraduate and graduate degrees in geology and geophysics, faculty members in the degree-granting departments in the geosciences, four year institutions offering less than a geology-geophysics major, and colleges and universities offering summer field courses in geology. • • •

Correction

On page 78 of the February issue the following publications were incorrectly listed under the Florida Geological Survey:

Thermodynamics of Fluorocarbon-Hydrocarbon Mixtures, Technical paper No. 165, gratis, 1959.
Studies in Binary Mixtures, Technical Paper No. 166, gratis, 1959.
Turbidity Effects in Natural Waters in Relation to Organisms and the Uptake of Radioisotopes, Technical Paper No. 167, gratis, 1959.
These papers can be obtained from **Florida Engineering and Industrial Experiment Station, University of Florida, Gainesville, Fla.**

Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries, ESL Bibliography No. 14, *Engineering Societies Library*, 29 W. 39th St., New York 18, N. Y., 33 pp., $2, 1960.—A selected list of references prepared for engineers and librarians concerned with organizing their own files or the files in the offices or libraries where they work. There is a subject index as well as an introduction in which selection and use of the systems are discussed. • • •

Third International Coal Preparation Congress, Liège—June 1958, *Institut National de l'Industrie Charbonnière*, 7 Blvd. Frere-Orban, Liège, Belgium, 790 pp., approx $12 (600 BF), 1960.——This volume, in English, contains the final versions of the papers and discussions, the speeches, list of members, general reports, etc. of the Congress. It deals with the present state and problems of coal preparation in the world.

Handbook of Heavy Construction, edited by Frank W. Stubbs, Jr., *McGraw-Hill Book Co. Inc.*, 1040 pp., $18.50.—The requirements of a construction job, the performance of major field operations, the operation and maintenance of equipment, and the best use of modern materials are surveyed in this book. Tables of data for figuring the costs of operating and owning equipment, the output of equipment, the economical use of materials, and other cost factors are included. There are specific chapters on excavators, tunnels, explosives, dewatering, precast and prestressed concrete, welding, bituminous pavements, cofferdams and caissons, pile driving, and many other aspects of heavy construction. • • •

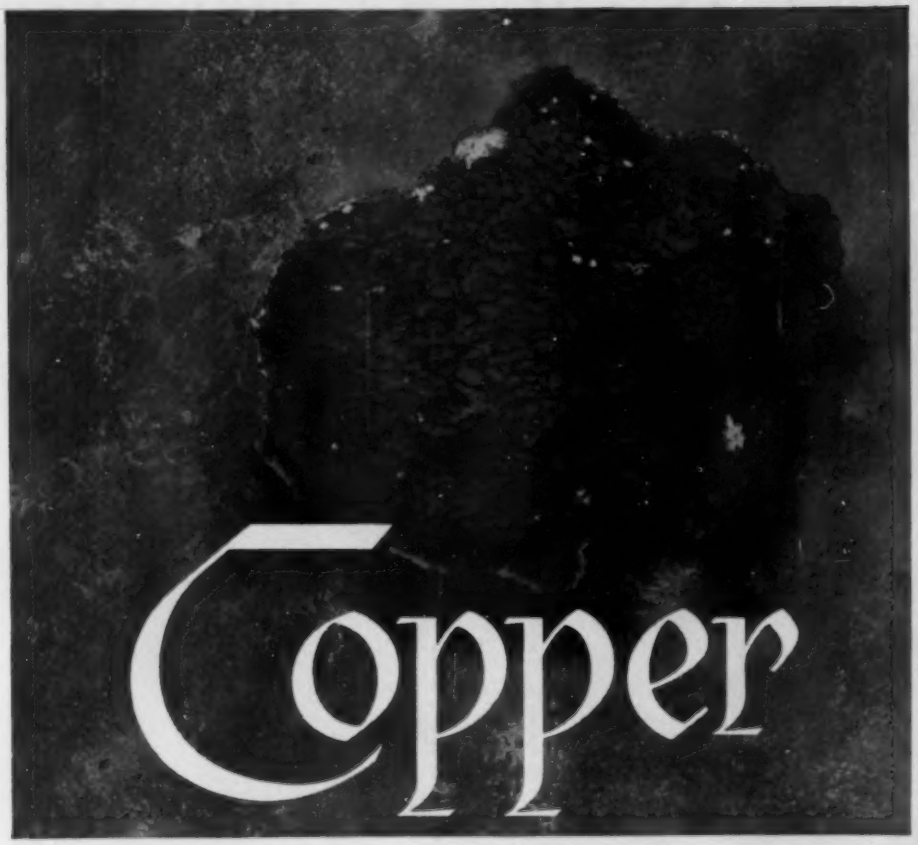
Principles of Mineralogy, by William H. Dennen. *The Ronald Press Co.*, 15 E. 26th St., New York 10, N.Y., 429 pp., $7.50, 1959.—An introduction to the subject, this text stresses the fundamental geometrical, chemical, and physical relationships of all matter. The first part deals with those phenomena of the solid state which are of direct and general concern in mineralogy, along with material on the physical properties and chemical testing of minerals. The second part is devoted to descriptions of individual mineral species or series, together with information applicable to appropriate mineral groups. • • •

Electrolytic Manufacture of Chemicals from Salt, by D. W. F. Hardie, *Oxford University Press*, 417 Fifth Ave., New York 16, N.Y., 74 pp., $1.20, 1959.—The production of chlorine, caustic soda, caustic potash, and metallic sodium by means of electrolysis of salt and potassium chloride is discussed. The processes and plant used and their design and operating conditions are described. Raw materials, the principal applications of the products, and methods of transporting them are also discussed. • • •

Civil Engineering Refresher for Professional Engineers License, by Robert Lipp, *John D. Constance*, 625 Hudson Terrace, Cliffside Park, N.J., $3.50, 1959.—A book to help prepare the practicing civil engineer to pass the civil engineering examination for professional engineer. Included are problems on surveying, highways, fluid mechanics, hydraulics, water supply and sewerage, structures, soil mechanics, and construction, obtained from past examinations of representative states. A reference source follows each solution and time-savers are offered for each problem. • • •

Oil Property Evaluation, by John M. Campbell, *Prentice-Hall Inc.*, approx. 512 pp., $9.00, 1959.—This volume covers in its three-part organization the economics concerning oil property evaluation; the calculation of reserves and prediction of future reservoir performance, including the tools available for the purpose and the many factors involved in their use; and the relation of the tools and elements previously discussed to the actual evaluation of oil property. • • •

(Continued on page 304)



. . . symbol of money and power

The name *copper* is from the Greek κυπρος, Cyprus, one of the early sources of the metal. Copper has often been called "the common man's gold"—and has become a symbol of *money* due to its wide usage in the coins of many nations, as well as a symbol of *power*—since the greatest usage of copper has been as a conductor of electricity.

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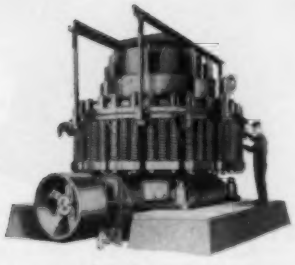

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. . . The machines that revolutionized crushing practice . . . **are built in a wide range of sizes, for capacities to over 900 tons per hour. Write for descriptive literature.**

NORDBERG MFG. CO., Milwaukee 1, Wisconsin

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SYMONS . . . a registered Nordberg trademark known throughout the world

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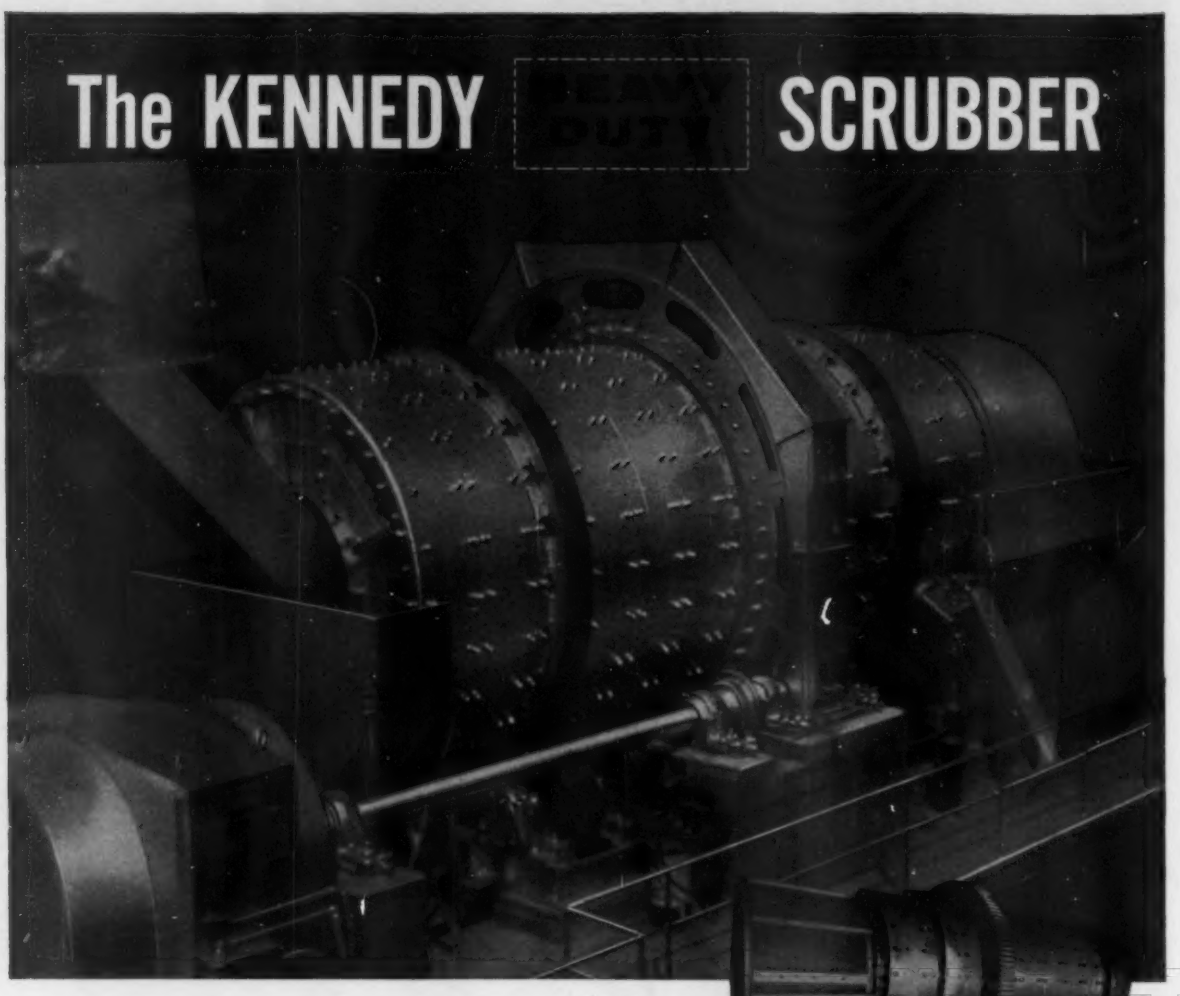
A Cleaner Product Is A More Saleable Product

The KENNEDY HEAVY DUTY SCRUBBER



With thoroughly cleaned rock or ore secondary and tertiary crushing and screening operations become more efficient. Control is improved and products are of higher quality. Downtime for blocked crushers or blinded screens is eliminated.

The KENNEDY Heavy Duty Scrubber is outstanding because of these features:

- All welded steel shell
- Wear resistant, replaceable liners
- Replaceable cast alloy lifters for advancing material
- Spherical roller bearings
- Cut gear and pinion
- Enclosed gear reducer drive
- Extra heavy structural steel base
- Counter flow of material and wash water
- Single, double or multiple trommel for dewatering and sizing

◆ *View showing rotary kiln type carrying stations with spherical roller bearing pillow blocks and extra heavy base.*

◆ *Discharge end of scrubber with double trommel. Dirt and clay wash through outer trommel; sized material discharges off end. Oversize discharges off end of inner trommel.*

Let us help you adapt this scrubber to your process.

KENNEDY VAN SAUN
MANUFACTURING & ENGINEERING CORPORATION
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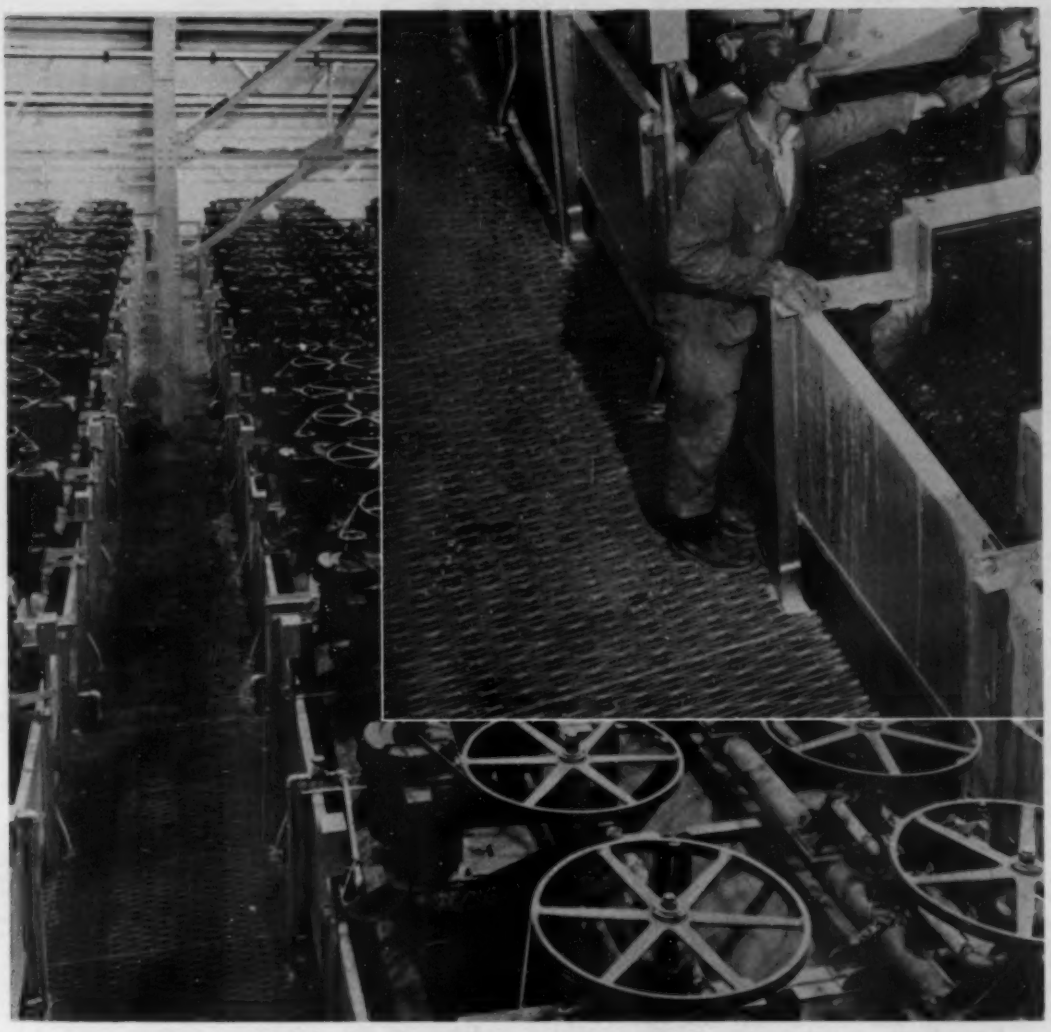
PRIMARY & SECONDARY GYRATORY CRUSHERS • JAW CRUSHERS • ROLL CRUSHERS • IMPACT BREAKERS • HAMMER MILLS • ROD & BALL MILLS • KILNS • KILN ACCESSORIES • DRYERS • SCREENS • MECHANICAL & PNEUMATIC CONVEYORS • COMPLETE CRUSHING, LIME, CEMENT & CARBON PASTE PLANTS. KENNEDY RESEARCH & TESTING SERVICE.

ACME Steel Flooring
At Anaconda's new El Salvador Plant



Steel flooring for walkways, stairways, and supports
from Acme help keep this modern plant clean and safe.

Acme Steel Engineering Company Inc.

917-937 South Howard Street
Baltimore 30, Maryland

specialists in steel construction—structural steel and miscellaneous iron

tanks • plate work • stacks • breechings • hoppers

BOOKS

Continued from page 300

Steel Workers and Technical Progress, A Comparative Report on Six National Studies, prepared by Mrs. O. Banks and J.-D. Reynaud, *Organisation for European Economics Co-Operation,* 1346 Connecticut Ave., N. W., Washington 6, D. C., 68 pp., $1.00, 1959.—This report is the outcome of a research project on the attitudes of workers in the steel industry to technological change carried out in Belgium, France Germany, Italy, the Netherlands, and the United Kingdom. It is not a summary of the findings but a short survey of some of the main conclusions to be drawn from the study.

Gold, by C. H. V. Sutherland, *Thames & Hudson,* 30 Bloomsbury St., London W.C. 1, England, approx. 200 pp., 35s ($4.90), 1959.—In this book, Dr. Sutherland stresses the beauty, power, and allure of gold but touches upon most aspects of the metal—historical, geological, and economical. • • •

Advances in Geophysics, vol. 6, edited by H. E. Landsberg, *Academic Press Inc.,* 111 Fifth Ave., New York 3, N. Y., 471 pp., $12.00, 1959.—This volume contains the proceedings of a symposium on atmospheric diffusion and air pollution held at Oxford, England, in 1958. The present status and future possibilities of atmospheric diffusion research are reported. General surveys of the atmospheric diffusion of pollutants and recent findings on atmospheric turbulence are discussed as well as the theory of turbulent diffusion, the diffusion of heavy or finite particles, transfer through the troposphere and stratosphere, the effects of thermal stratification on diffusion, and pollution patterns from point and area sources. • • •

Physics of the Earth's Interior, by Beno Gutenberg, vol. 1, International Geophysics Series, edited by J. Van Miegham, *Academic Press,* 111 Fifth Ave., New York 3, N. Y., 240 pp., $8.50, 1959.—A survey of the present status of knowledge in this field. Contents include: fundamental problems and data; the structure of the earth, the earth's crust, the mantle of the earth, the core, temperature and thermal processes in the earth, density, pressure, gravity, and flattening in the earth, elastic constants and processes in the earth, nonelastic processes. Seismology is touched on only insofar as investigations in the field bear upon the structure of the earth and the physics of its interior as this subject will be treated in detail in another monograph. • • •

Mining Accounting in Canada by A. J. Little and W. L. MacDonald, *The Canadian Inst. of Chartered Accountants,* 69 Bloor St. E. Toronto 5, Ont., Canada, 72 pp., $3, 1960.—This book deals with accounting practices adopted by major companies in the mining industry, with special emphasis on depletion, inventory valuation, and the effect of income tax legislation. Many of the accounting problems in the mining industry are unique and this book provides a clear and concise explanation of the treatment of some of these problems. • • •

WANTED

Used 54" x 70" Bird Solid Bowl Centrifugal Filters with or without controls and drive motors.

Mountaineer Coal Co.
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Fairmont, West Virginia
Phone: 1000

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

The Anaconda Co.'s El Salvador Operations—El Salvador is in the Chilean Andes, some 65 miles inland and about 8500 ft above sea level. Mine, plant, and townsite are in virgin country—barren, mountainous terrain traveled until now by few humans other than the Incas, whose historic trail can still be seen where it crosses the property.

Initial operations at this $100 million project of Andes Copper Mining Co. were preceded by nearly three years of planning and development. A 2½-mile tunnel was driven to haul ore from the mine to the new 24,000-tpd concentrator, 14 miles of pipeline were laid to convey slurry from the plant to the rail loading point at Llanta, and 18.4 miles of pipeline were added to the water supply system. **Ref.:** MINING ENGINEERING, **April 1960, p. 339.**

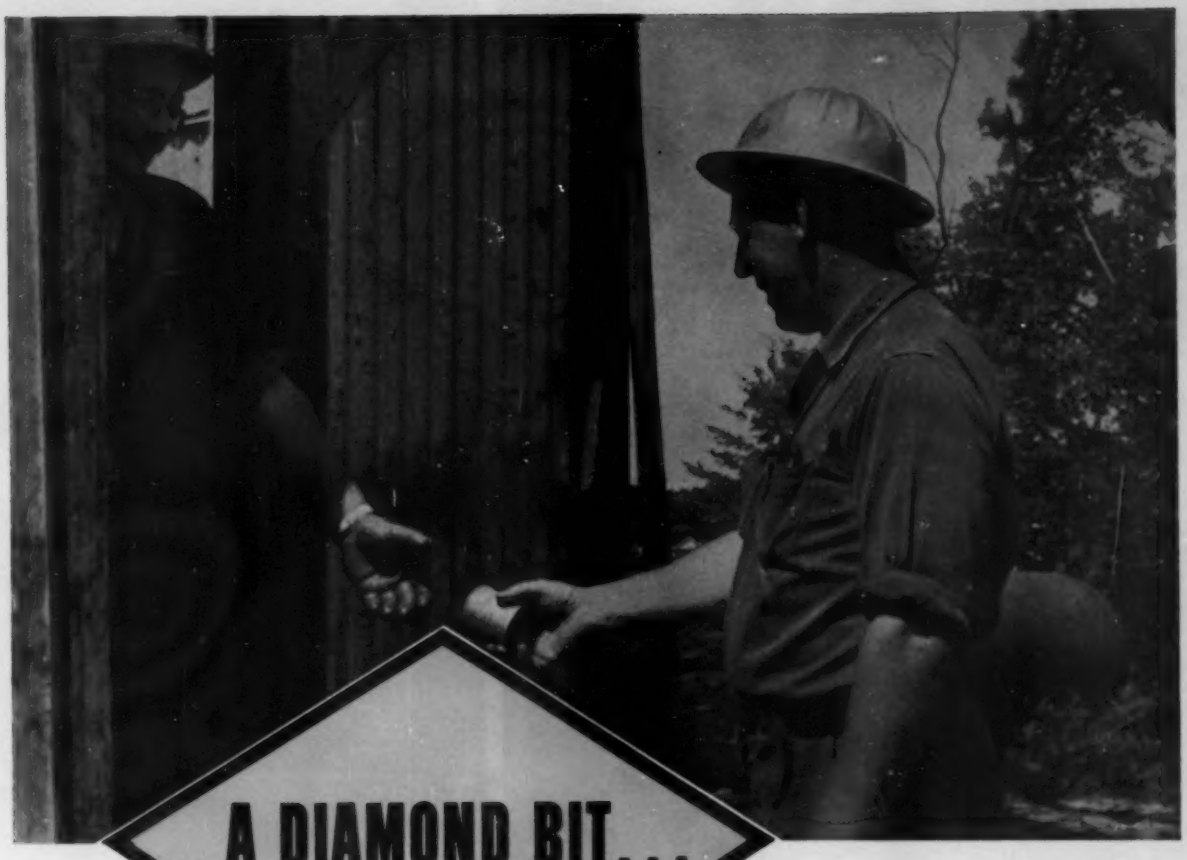
SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available* **only if followed by a preprint order number.** *These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N. Y.*

Development of the Technology of the Beneficiation of Hematite Ores by *N. P. Titkov and A. N. Yegorkin*—In the report is given an account of laboratory and semi-industrial investigations of development of rational schemes of beneficating various hermatitic ores of Krivoi Rog, Kursk magnetic anomaly, and other seams. They were subjected to gravitational magnetic (in a strong field) flotational and a reduced magnetic concentration. Depending on the mineralogical composition of the ore and impregnated mined and unmined minerals, a rational scheme of beneficiation was developed. In the report is shown the dependence of technological characteristics of various methods of beneficiating from the contents of quartz and iron silicates in the ore. **AIME Annual Meeting, New York, February 1960. 60B100**

Recedence of Aqueous Films Hydrophobic Surfaces by *D. W. Fuerstenau*—Flotation depends on the replacement of a solid-liquid interface with a solid-air interface. The rate at which this replacement occurs was investigated by measuring the velocity at which aqueous films recede from a hydrophobic pyrex surface as a function of the concentration of dodecylammonium acetate in solution and the thickness of the film. The velocity with which aqueous films recede from the amine-coated pyrex increases markedly if the runs are repeated at short time intervals, probably because of increased adsorption of the heteropolar reagent. However, the recedence velocity on paraffin was found to depend only upon film thickness, independent of the number of trials. These phenomena can be correlated with flotation behavior. *Joint Meeting, SME, MBD-American Chemical Society, Div. of Colloid Chemistry, Atlantic City, N. J., September 1959.*

Studies of the Surface Topography of Silica by *D. J. C. Yates*—Two types of adsorption sites exist on silica surfaces. One is the strongly bound surface OH groups, and the other is the oxygen (or possibly the silicon) surface atoms. Evidence, of a direct nature, of the existence of these OH sites has only been available since the application of infrared spectroscopy to surface studies. Detailed investigations show that there are at least two types of OH sites. In one the hydrogen atom is fairly free of the influence of the surface, the so-called "free" OH groups, and in the other the hydrogen is hydrogen bonded to other surface atoms. The effects of these OH groups has been investigated both spectroscopically and by length-change techniques. In particular, studies using ammonia, methyl chloride, acetone, water and methyl alcohol are discussed. The latter two adsorbates are especially interesting as they contain OH groups which can interact with the silica OH groups. *Joint Meeting SME, MBD-American Chemical Society, Div. of Colloid Chemistry, Atlantic City, N. J., September 1959.*

The Stability, Contact Angle, and Surface Tension of Teflon Dispersions in Water by *N. L. Jarvis and W. A. Zisman*—The stability of a dispersion of solid Teflon particles in water depends upon the surface tension (γ_{LV}) of the solution. When γ_{LV} approaches the critical surface tension (γ_c) of Teflon (18-19 dynes/cm), the contact angle approaches zero. This offers a useful method for increasing the stability of such dispersions. Fischer and Gans showed empirically that γ_{LV} for aqueous solutions of any conventional wetting agent does not go below 26-27 dynes/cm at 20°C. A theoretical limiting value of about 22 dynes/cm at 20°C can be predicted for any conventional wetting agent from consideration of the minimum value of γ_c of a solid surface comprised of hydrocarbon groups. Lower values cannot be expected even when mixtures of conventional wetting agents are used. An explanation also follows for the minimum surface tensions reported in early investigations of the effect of surface-active impurities on the surface tensions of conventional wetting agents. It is concluded that mixtures of conventional wetting agents cannot result in zero contact angles with Teflon nor in maximum stability of these dispersions. When the hydrophobic radical of the surface-active agent is a perfluoroalkane, γ_{LV} for the aqueous dispersions can be reduced considerably below γ_c; and this can result in increased stability of the Teflon dispersion. Consequently, more stable, reproducible dispersions of Teflon can result through proper choice of wetting agents and adequate control of the surface tension. Casell's modification of the maximum bubble pressure method was found especially suitable for measuring the surface tensions of concentrated dispersions. *Joint Meeting, SME, MBD-Americas Chemical Society, Div. of Colloid Chemistry, Atlantic City, N. J., September 1959.*



A DIAMOND BIT...

Custom designed by Christensen for your drilling requirements

Whatever your drilling needs—underground or on the surface, exploration or blast holes, shallow or deep drilling with air, water or mud—you'll find that Christensen Diamond Bits are your assurance of drilling at "less cost per foot."

Christensen Diamond Bits cut straighter holes, last longer and cut even the hardest rock economically.

And, regardless of your job location or scope of operations, there's an experienced Christensen field consultant available to recommend the right "custom designed" bit for your job. This means that you can be confident that the diamond size and pattern, waterways, matrix hardness and bit style correctly meet your drilling conditions.

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CHRISTENSEN DIAMOND PRODUCTS

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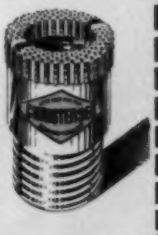
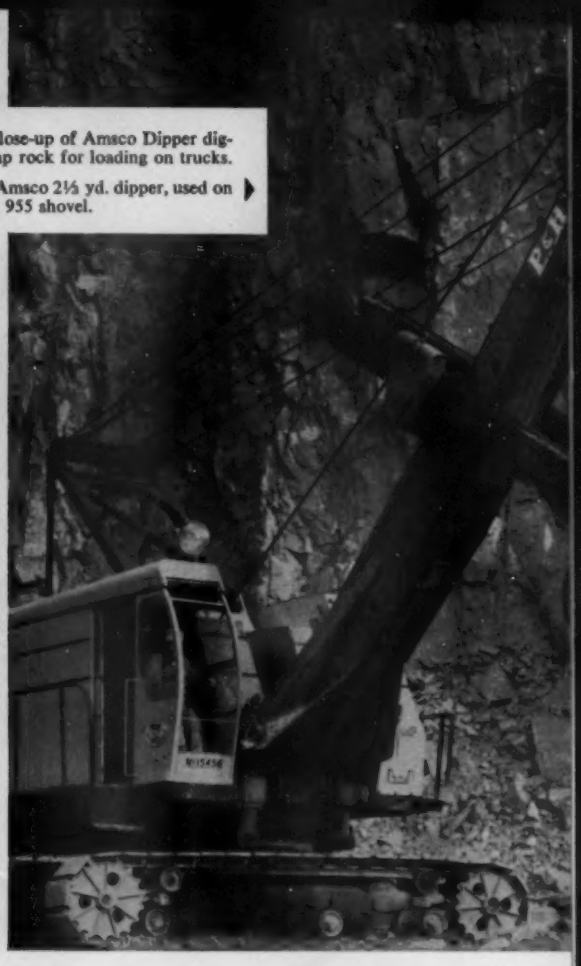
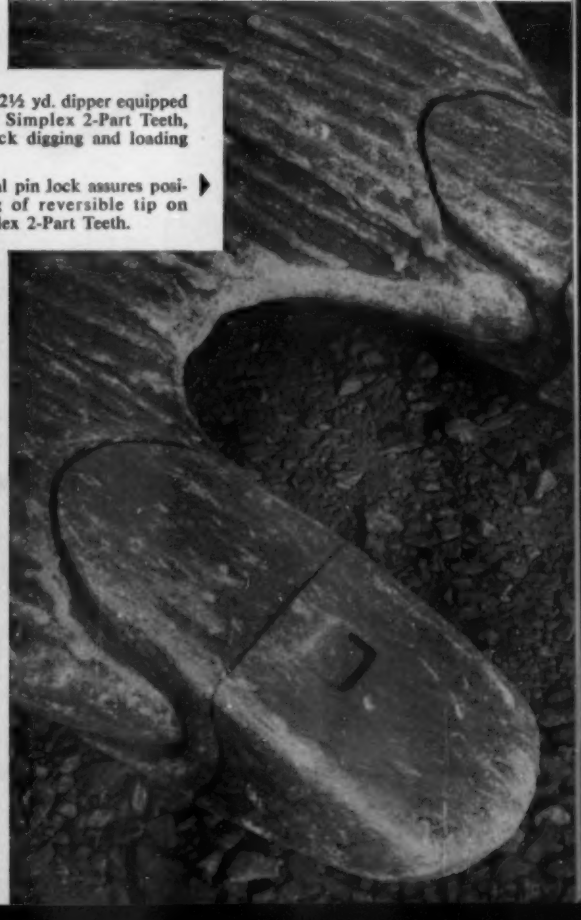


To obtain faster penetration, straighter holes, better diamond usage, unequalled service and experienced consultation, contact Christensen.



Left: Close-up of Amsco Dipper digging trap rock for loading on trucks.

Right: Amsco 2½ yd. dipper, used on P. & H. 955 shovel.



Left: Amsco 2½ yd. dipper equipped with Amsco Simplex 2-Part Teeth, used for rock digging and loading at quarry.

Right: Special pin lock assures positive locking of reversible tip on Amsco Simplex 2-Part Teeth.

More proof that...

AMSCO HELPS YOU MOVE MORE TONS PER DOLLAR

Read about the actual experience of a large New England quarry with Amsco Dippers and Simplex 2-Part Teeth*

"WE HAVEN'T WORN OUT AN AMSCO DIPPER IN 5 YEARS"

This, in the words of the quarry superintendent, sums up his experience with Amsco Manganese Steel Dippers. It's rugged work, all in rock, as you see from the pictures at the left. Shovel and dipper are used to load trap rock onto trucks for transportation to the crushing plant.

The Amsco Dipper was installed because the superintendent had used them before, and knew their reputation for long life under tough digging conditions. Experience is proving him right . . . again.

SIMPLEX TEETH HANDLE 25,000 YDS. OF ROCK BEFORE REPLACEMENT

At this same quarry, Amsco Simplex 2-Part Teeth are giving 120 hours' service . . . handling 25,000 to 30,000 yards of rock . . . before replacement is necessary. That's considerably longer service than has been obtained from competitive 2-part teeth, the quarry superintendent states.

Not only is the wear-life of these teeth exceptional, but operators like the ease of replacement, and the fact that the tips stay on without trouble.

For further information on Amsco Dippers or Simplex 2-Part Teeth, see your power shovel equipment dealer, or write to Amsco for technical bulletins showing sizes, types and application data. *Patent No. 2,901,908

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

Other plants in: Denver • Los Angeles • New Castle, Dela. • Oakland, California • St. Louis
In Canada: Joliette Steel and Manitoba Steel Foundry Divisions

BLASTING IS OUT— D9 AND RIPPER IN— PRODUCTION UP 35%

Gillen Coal Mining, Inc., is salvaging a six-ft.-thick seam of coal near Carbondale, Pa. To get to the coal, 180 ft. of overburden must be removed—10 ft. of topsoil, 100 ft. of hardpan and, finally, 70 ft. of rock.

Gillen used to blast through. Then they changed to a Caterpillar D9 Series E Tractor with a No. 9 Ripper. Production shot up 35%. Cost savings are estimated to be *60%!*

The overburden, rough as it is to work with, is the kind of material the D9 and No. 9 Ripper eat up. Working in 50-ft. passes, the team fragments the hardpan (average cu. yd. weight 3200 lb.) into right-size pieces for two Cat DW21s. They're moving up to 4000 yd. a seven-hour shift. When needed, the D9 pushloads the scrapers and 'dozes, too.

The D9 and No. 9 is an all-business combination of power and speed. The Series E Model D9 has a 335 HP (flywheel) turbocharged engine to put massive power into the work. You get more power from every gallon of fuel. The Series E D9 has a heavier undercarriage. Track components are bigger, heavier. You get up to 40% more life with deeper hardened steel shoes, links and rollers. A new equalizer bar makes the Series E D9 even more stable.

New power shift transmission gives you the flexibility and anti-stall features of a torque converter with the split-second snap of direct drive. Finger-tip control gives operators instant changes under full load without clutching.

Match this with the No. 9 Ripper to break your way through production bottlenecks. For the right tractor-ripper combination, see your Caterpillar Dealer, who will prove his recommendation with a demonstration.

Caterpillar Tractor Co., General Offices, Peoria, Ill., U.S.A.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

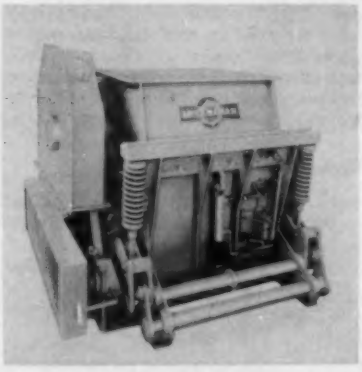
WANTED—
THE HARD WORK

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

Two-Stage Crusher

McLanahan and Stone Corp. has announced a modified two-stage Triple-Roll Crusher for very high-production operations. Two basic elements—a single roll crushing primary feed against a curved crushing plate, and a double roll below for performing secondary reduction—are combined with new automatic toggles for protection against tramp iron. **Circle No. 1.**



Magnetometer

The Abem Co. is now producing the MZ-4 Magnetometer, a vertical variometer for ore prospecting and oil exploration. Utilizing the torsion principle, the unit operates easily, has high accuracy, and wide measuring range. **Circle No. 2.**

Core Barrels

Recently designed "Series 10" Wire Line core barrels by *E. J. Longyear Co.* permits rapid recovery of cores up to 25% larger in diameter than previously possible for AX, BX, and NX Wire Line barrels without changing the present size of drill holes or drill rods. Featured is an overshot latching device which releases a special inner tube of the core barrel for hoisting to the surface while drill rods, bit, and core barrel outer tube remain in the hole. The drill string is withdrawn only for changing of bits. In addition, new bits used with "Series 10" barrels have a reduced diamond carat weight but have increased penetration speed and bit life. Other cited advantages are decrease in "caving", instant awareness of core blocks, and ability to recover core as often as necessary when frequent blocking makes core runs very short. The "Series 10" Wire Line barrels replace the original series but the Wire Line drill rods have not been changed. **Circle No. 3.**

Raise Climber

The *Vulcan Iron Works* (Denver) is now selling the Swedish engineered Alimak Raise Climber. The unit, fully self-contained for driving raises up to 1200 ft, has rack equipped guide rails, portable steel elevator, and accessories. Lines for air, water, electricity, and phone are housed in the guide rails allowing one man to perform all raise-driving functions with finger-tip control. **Circle No. 4.**

Flexible Metallic Belt

Announcement of the development of a flexible but non-woven metallic belt for drum filters has been made by *The Eimco Corp.* The belt is composed of individual, rigid, wedge-shaped bars attached by flexible wires or coil springs allowing easy replacement of a section if damage occurs. **Circle No. 5.**

Metal Sheet

A pierced metal sheet, Conidure, has been introduced by *Cross Perforated Metals, National-Standard Co.* For screening, recovering, or dewatering coal, aggregate, chemical solutions, and other solids-bearing liquids passing through gravity or centrifugal separators, it is reported to last three times longer than perforated metal and to allow a substantial increase in throughput. **Circle No. 6.**

Underdrain Pipe

Transite Underdrain Pipe, a perforated asbestos-cement pipe developed by *Johns-Manville* to solve many problems encountered in sub-surface drainage, features several installation and performance advantages. The pipe has great crushing strength allowing an economical wall thickness of good weight-strength ratio. Its smooth, uniform interior and resistance to corrosion is reported to assure a lifetime of low frictional resistance to water flow. **Circle No. 7.**

AN Pellets

Ammonium nitrate in new pellet form said to increase economy and effectiveness of AN blasting has been announced by the *Atlas Powder Co.* Described as of optimum size and shape for better control over borehole density and oil absorption, the pellets flow freely and may be field-mixed by any method. Also available in pre-mixed form. **Circle No. 8.**

Man Mine Car Control

A semi-automatic explosion-proof control developed by *Allis-Chalmers* for man mine cars permits safer and speedier transportation of miners to their job sites. The device consists of a control panel, a dynamic brake pushbutton, and a remote pistol-grip master switch which will turn to "off" when operator removes hand from grip. It provides automatically controlled acceleration at speeds four to five times faster than the conventional mine locomotive. **Circle No. 9.**

Cable Control Units

International Harvester Co. now has available two new planetary-drive cable control units designed to handle the heavier equipment developed as matching units for the recently-announced TD-25 crawler. Front-mounted Model 160 is a single-drum, heavy-duty, fast acting, easy-operating control. Rear-mounted Model 260 is a double-drum control with a four-gear planetary system for each cable drum. **Circle No. 10.**

Chain Cutter Bit

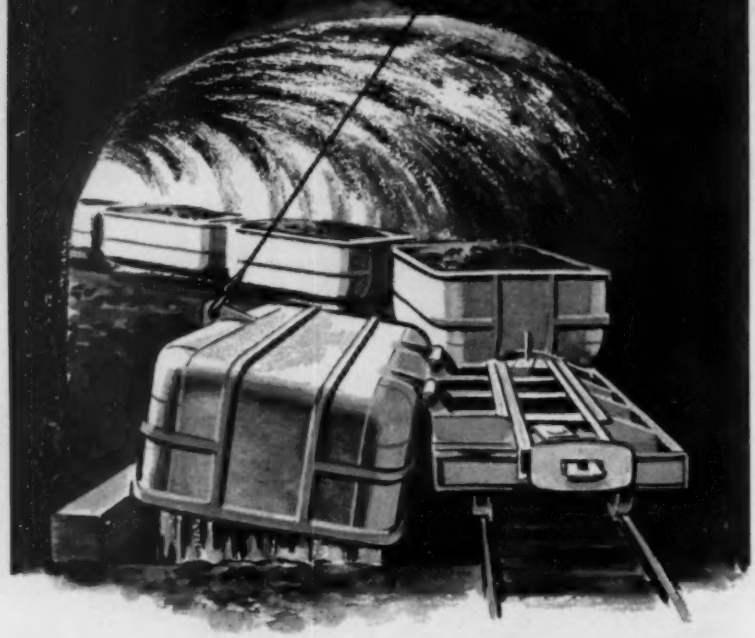
Vascoloy-Ramet Corp. is offering a rugged chain cutter bit for Jeffrey type continuous miners. Designated as style CHJ, it features a wide (¾") nose. Rigidity is provided by a flange which prevents wobbling, carbide breakage, packing of cuttings, and assuring high resistance to side bending. **Circle No. 11.**

Big Hole Drilling

The *Hugh B. Williams Mfg. Co.* has announced the addition of hard rock rotary drilling equipment for the mining industry. Specializing in big hole drilling equipment, their line includes large diameter plate type bits, rotary tables, and swivels, plus splined tool joint drill pipe. **Circle No. 12.**

(Continued on page 310)

KERMAC SOLVES AMBROSIO LAKE SLIMES
WITH TELLURIDE TYPE CARS

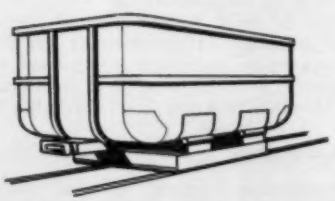


THE TOUGH ONES COME TO **Card**

Kermac Nuclear Fuels Corporation is operating four major wet mines in the Ambrosio Lake area of New Mexico. Slop-forming shale lenses interbedded in the ore help form a watery muck that flows easily when handled but sticks tightly to machinery, pockets and car bodies when allowed to settle. To solve this tough problem, Card furnished a string of 40 special "Telluride Type" cars that feature a solid body for side dumping and intense shaking. The cars range from 77 cu. ft. to 110 cu. ft. capacity.

Following successful introduction of the first lot of those heavy duty Card cars, Kermac Nuclear has placed additional orders which will provide them a complement of 82 cars of this type. No haulage troubles have been encountered with these cars, and resulting haulage costs are satisfyingly low.

Solve your haulage with an economical Card design. Our engineers can supply an efficient car to meet your most difficult specifications.



C.S.Card Iron Works Co.
2501 WEST 16th AVE.
DENVER, COLORADO

Lab Flotation Machine

The Booth Co. has developed a laboratory flotation machine which is a carefully proportioned scale-down of the aerating mechanism of commercial size Booth Flotation Machines. Flotation data from the laboratory machine is interpolated directly into plant requirement estimation for commercial size machines. With greater efficiency reported over other types of machines, it also features simplicity and ease of operation, corrosion and abrasion resistance, excellent conditioning characteristics, plus adjustable rotor speed and height of aerator. **Circle No. 13.**

Manhole Cover

A quick-opening manhole cover designed by *Allis-Chalmers Mfg. Co.* permits dumping a grinding-mill load for speedy and efficient maintenance servicing. A simple operation converts the regular cover to the temporary manhole cover. **Circle No. 14.**

News & Notes

Bucyrus-Erie Co. is building a mammoth stripping shovel, the world's largest mobile land machine, for the *Peabody Coal Co.* With a dipper

capacity of 115 cu yd, the shovel will be more than twice the size of any present shovel. It is expected to be in operation about August, 1962. . . . *Western-Knapp Engineering Co.* has opened a new office in Hibbing, Minn. . . . *The Eimco Corp.* has been granted U. S. and foreign patents on the rocker arm rail used on the *Eimco* Model 630 Excavator Loader and other RockerShovels. . . *Caterpillar's* new line of wheeled Traxcavators is manufactured at the recently completed Aurora, Ill., plant . . . Approximately $4,000,000 will be invested in new construction and equipment modernization of Refractories Division plants of *H. K. Porter Co., Inc.* at Bessemer, Ala., and Wellsville, Ohio, according to C. L. Holbert, *Porter* President.

(21) WELDING AND CUTTING: *Air Reduction Sales Co.* has available a revised 36-page catalog covering its expanded line of gas welding and cutting hand torches, outfits, tips, and accessories. A general description, features, specifications, and photographs are supplied for each product. Specification charts to assist proper selection for both general purpose and special gas welding and cutting are included.

(22) TRUCK CRANE: The versatility and time saving features of the American 200 Series 22½-ton truck crane are described and illustrated in Catalog 732-TG-2 from the *American Hoist & Derrick Co.* The 20-page publication also contains on-the-job photographs of the crane.

(23) CAR SHAKER: Information about a 3½-ton car shaker designed for plants where unloading of hopper-bottom cars does not warrant installation of a 5-ton unit and where smaller capital investment is desirable is available in Bulletin 26B9438 from *Allis-Chalmers Mfg. Co.*

(24) SLUSHERS: Two bulletins from *Joy Mfg. Co.* describe the firm's line of electric driven slushers and the newly developed 5-cylinder light-weight air driven slushers. Bulletin 76-F supplies data on a compact 5 hp model with a rope pull of 1100 lbs. Bulletin 76-G discusses a slusher of 7½, 10, and 15 hp with maximum pull of 2500 lbs.

(25) IDLERS: A 48-page engineering and product information booklet on belt conveyor idlers has been issued by *Hewitt-Robins Inc.* Included are details of construction, comparison of ten competitive designs, selection procedure, engineering tables, dimensions, and specifications. Also included are descriptions of the basic types of idlers for all purposes.

FREE LITERATURE

(26) STEEL CASTINGS: A six-page brochure from *Farrell-Cheek Steel Co.* contains descriptive information and photographs of a variety of electric furnace alloy and carbon steel castings. Included are traveling standard choker hooks, chain, sprockets, sheaves, snatch block sockets, wheels and rollers, tooth gears and pinions, bar benders and cutters. Also listed are more detailed equipment catalogues that are available upon request.

(27) DUST COLLECTORS: "Freedom from Dust", a 28-page illustrated brochure from *Dracco Division of Fuller Co.*, lists a complete range of dry collection equipment for gathering waste dust or returning valuable, reusable material to the manufacturing process. Information and specifications of cloth filtration and cyclonic equipment are supplied.

(28) COST GUIDE: For better estimation of earthmoving costs, request *International Harvester Co.'s* 76-page book entitled "Basic Estimating". A guide for proper equipment application plus methods for estimating hourly production, fixed and operating costs, and individual machine capabilities are provided. Illustrated with charts, diagrams, formulae and 15 pages of reference data, the book is available through the firm's local distributors.

(29) SURFACE AGENTS: *The Onyx Oil & Chemical Co.* has published its 50th anniversary catalog of surface active agents. Each product is described by trade name, active ingredient, percent activity, physical state, general use, specific applications and properties.

(30) CENTRIFUGAL SEPARATOR: *Baker Perkins, Inc.*, is offering a multi-stage, push-type centrifugal separator which reportedly allows more thorough washing of cake with minimum wash liquor and increased cake dryness. Cut-away views and specifications on seven models is provided in a four-page brochure.

(31) FLOW METERS: A brochure from *Brooks Rotameter Co.* describes and illustrates their full line of rotameters. Basic advantages of variable area flow meters are reported and displays of various types of meter applications are included.

(32) POWER SHOVEL: Recently issued is a 24-page catalog on Lorain's 2½ yd L85A power shovel by the *Thew Shovel Co.* Also available as a crane, clam, dragline, and hoe, it features a 10-yr warranty on "Shear-Ball" connection, two-lever joy stick controls, and square-tubular-chord crane boom.

(33) SLUDGE COLLECTORS: An informative, detailed 28-page book entitled "Circuline Sludge Collectors" presents *Link-Belt Co.'s* complete line of six series and 15 types of collectors now available for water, sewage, and industrial waste treatment settling tanks. Engineering drawings are included.

(34) LUBRICATION SYSTEMS: A revised 24-page general brochure containing information on the complete line of centralized systems of lubrication and illustrations of typical applications is offered by *Farval Division of Eaton Mfg. Co.* The advantages, principles of operation, and components of the systems are depicted.

(35) CRAWLER TRACTORS: The recently announced International TD-25 diesel crawler tractor is the subject of the new 24-page catalog CR-791-I from *International Harvester Co.*

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4

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51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(36) ROCK BITS: Tungsten carbide rock bits are discussed in Bulletin NR-87-C from *Joy Mfg. Co.* Bottom drive, shoulder drive, and taper socket bits are illustrated and explained. A chart providing selection data for all types of bits made by *Joy* is included.

(37) HAMMERMILLS: Bulletin HM-2 from *Iowa Mfg. Co.* supplies information about the advantages, exclusive features, and serviceability of Cedarapids hammermills. The high quality and uniformity of the crushed product is also cited.

(38) CONTROL PANELS Selection of the right control panel for automatic materials handling systems is the subject of Bulletin G-9 from *Fuller Co.* The 12-page booklet describes and illustrates four basic types; "walk-in" master control panel, floor and wall-mounted types, and explosion-proof type. Specific examples of their use within the mineral industry are provided.

(39) WALL CHART: An informative, colorful wall chart containing valuable data for users of resistance welding electrodes and accessories is available from *Ampco Metal, Inc.* The 20½" x 29½" chart includes R.W.M.A. specifications for spot-welding similar and dissimilar metals, projection welding data, conversion data on commonly welded metals, and spot welding and seam welding schedules for low-carbon steel.

(40) DEMINERALIZERS: A new line of standardized demineralizers designed for process water applications is described in Bulletin 5819 from *Cochrane Corp.* Information on use of demineralization process eliminating variables in water and their effects on product quality control is supplied.

(41) PERMANENT MAGNET PULLEYS: Bulletin No. 1022 from *Stearns Magnetic Products* furnishes pertinent data on the enlarged line of Indox V permanent magnet pulleys. The barium ferrite ceramic material is reported equal in performance to electro-magnetic pulleys but less expensive.

(42) CATALOG: The 1960 catalog and price list is now available from *Soiltest, Inc.* The 300-page, 3400-item book describes and illustrates engineering test equipment from a pocket penetrometer to completely equipped mobile testing laboratories. For your copy, write on company letterhead to Soiltest, 4711 West North Ave., Chicago 39, Ill.

(43) VIBRATING FEEDERS: *Link-Belt Co.* has published a 12-page catalog entitled "MC Vibrating Feeders". The entire line of single and twin motor feeders of floor mounted or cable suspended types plus feeders with pre-designed hoppers and special modifications are discussed.

(44) IDLERS: The series 200 Limberoller belt conveyor idler, an improved version of the original two-bearing catenary idler, is thoroughly described in a 20-page bulletin from *Joy Mfg. Co.* It consists of neoprene discs molded to a flexible steel wire cable. Cable strain is reduced by free swiveling bearing mounts and extra reinforcement between end discs.

(45) ANALYTICAL LABORATORY: A pamphlet illustrating the facilities and operation of *Spectrochemical Laboratories* is now available. The firm specializes in analyses and quality control of metals, minerals, oils, chemicals, ceramics.

(46) EXCAVATORS: Performance of Eimco 105 excavators on three tunnel projects are outlined in Bulletin L-1091 from *The Eimco Corp.* Data in English and metric specifications is supplied on the Glen Canyon Dam Tunnels, the Ft. Pitt Tunnels, and Mammoth Pool Diversion Tunnel.

(47) ROLLER CHAINS, SPROCKETS: *Dodge Mfg. Corp.* describes and illustrates its expanded line of roller chains and sprockets in their 56-page bulletin A691. Discussion of roller chains including single strand, double strand, double pitch drive and conveyor, and standard attachments plus Taper-Lock sprockets, bushings, and chain couplings is accompanied by selection data and list prices.

(48) COMPRESSORS: *Atlas Copco* has available a four-page folder describing its "Twin-Air" rotary screw type air compressors which deliver from 6,900 to 19,400 cfm of air at 110 psi. Discussion of the compression principle, design features, operational advantages and machine dimensions is included.

(49) EARTHMOVING: How seismic methods can aid construction work is told in "Ripping With Seismic Analysis", an eight-page brochure from *Caterpillar Tractor Co.* The bulletin tells how earthmoving costs of some compact materials can be reduced by use of crawler-drawn rippers instead of blasting, and discusses principles, methods, and operating techniques of simple seismic analysis for evaluating the depth and degree of consolidation, or rippability, of each subsurface rock layer.

(50) CENTRIFUGAL COMPRESSORS: Condensed procedures for rapid selection of single-stage centrifugal compressors for air applications are described in two bulletins from *Allis Chalmers Mfg. Co.* Bulletin No. 16B9485 discusses standard B style close-coupled or overhung type up to 3.0 lbs equivalent air pressure; No. 16B9486 gives sizing procedure for standard C style pedestal mounted, ball bearing type up to 4.0 lbs equivalent air pressure.

(51) DRILLING EQUIPMENT: The *Acker Drill Co.* has issued a 28-page bulletin describing their complete line of diamond bits, core barrels, rotary rock bits and drag type bits. More than 50 illustrations and cut-away diagrams are contained in the booklet. Ask for Bulletin 10.

(52) DUST FILTER: An eight-page bulletin containing details of the improved design "RJ" dust filter is available from *The Day Co.* The simple operating principle and efficiency of the filter are high-lighted in the booklet which also discusses operating cost savings and versatility of the unit.

(53) MOTORS Bulletin No. 196 from *Sterling Electric Motors, Inc.*, describes their new line of drip-proof motors designed to replace totally-enclosed motors where adverse conditions of moisture, humidity, dust, oil, and chemicals prevail.

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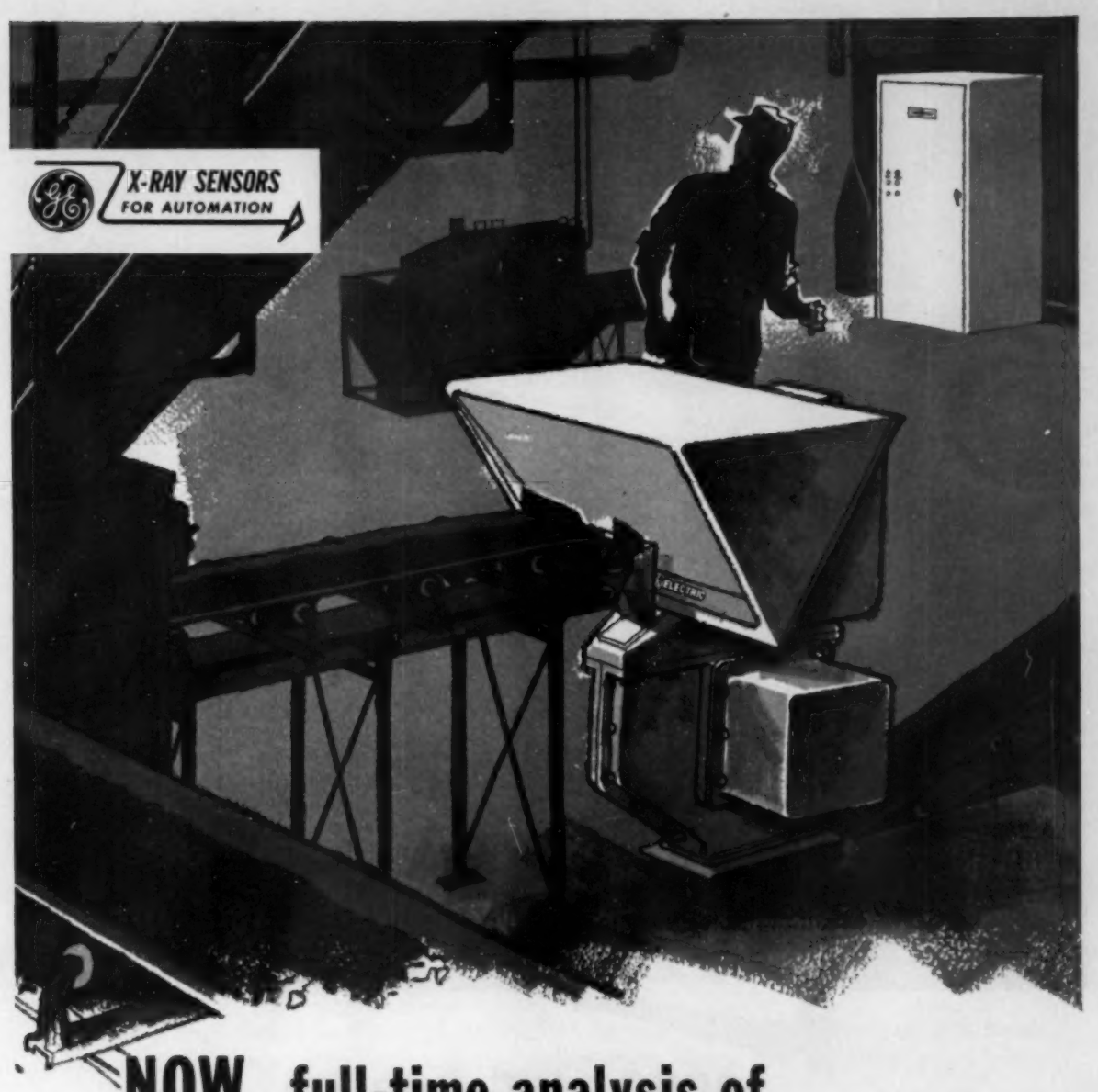

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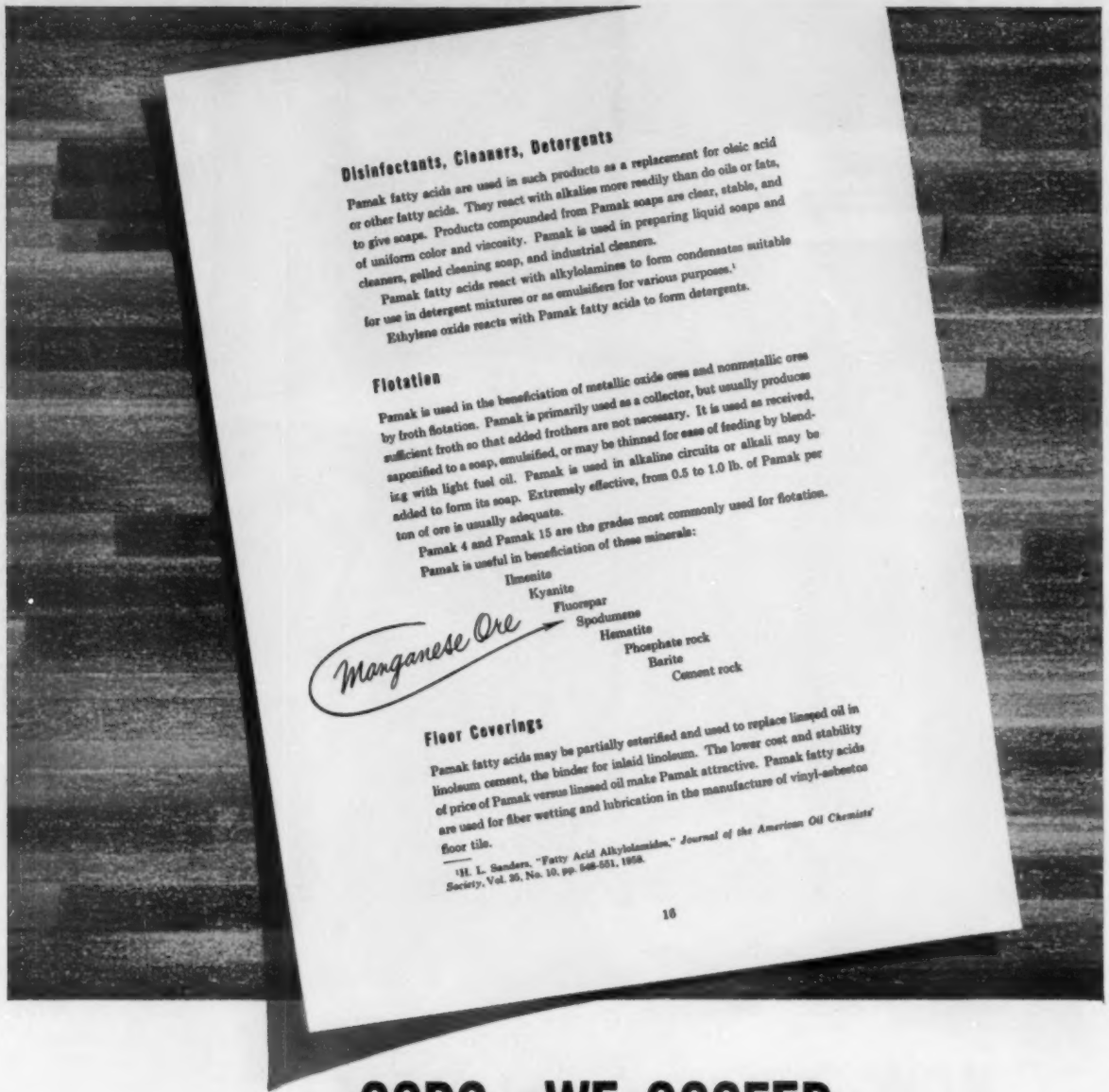
Disinfectants, Cleaners, Detergents
Pamak fatty acids are used in such products as a replacement for oleic acid or other fatty acids. They react with alkalies more readily than do oils or fats, to give soaps. Products compounded from Pamak soaps are clear, stable, and of uniform color and viscosity. Pamak is used in preparing liquid soaps and cleaners, gelled cleaning soap, and industrial cleaners.
Pamak fatty acids react with alkylolamines to form condensates suitable for use in detergent mixtures or as emulsifiers for various purposes.[1]
Ethylene oxide reacts with Pamak fatty acids to form detergents.
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Pamak is used in the beneficiation of metallic oxide ores and nonmetallic ores by froth flotation. Pamak is primarily used as a collector, but usually produces sufficient froth so that added frothers are not necessary. It is used as received, saponified to a soap, emulsified, or may be thinned for ease of feeding by blending with light fuel oil. Pamak is used in alkaline circuits or alkali may be added to form its soap. Extremely effective, from 0.5 to 1.0 lb. of Pamak per ton of ore is usually adequate.
Pamak 4 and Pamak 15 are the grades most commonly used for flotation.
Pamak is useful in beneficiation of these minerals:
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Kyanite
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Spodumene
Hematite
Phosphate rock
Barite
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Pamak fatty acids may be partially esterified and used to replace linseed oil in linoleum cement, the binder for inlaid linoleum. The lower cost and stability of price of Pamak versus linseed oil make Pamak attractive. Pamak fatty acids are used for fiber wetting and lubrication in the manufacture of vinyl-asbestos floor tile.
[1] H. L. Sanders, "Fatty Acid Alkylolamides," Journal of the American Oil Chemists' Society, Vol. 35, No. 10, pp. 548-551, 1958.
16

OOPS—WE GOOFED

PAMAK® IS IDEAL FOR MANGANESE ORE, TOO

We can't even blame it on a copyreader, but when we printed our new booklet on Pamak, Hercules fatty acids from tall oil, we unintentionally omitted manganese ore from the list of materials where Pamak is exceptionally useful as a flotation agent. But we have *not* omitted our thorough research and technical service, and the high quality that consistently marks our product. If you already have your copy of this booklet, we hope you'll remember that manganese belongs. If you haven't received a copy, you'll certainly want one for your files. A postcard to Hercules will bring you your copy.

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Whether your choice is the 225-hp HD-21 or the 150-hp HD-16, you get from 8½% to 27% more efficient engine operation than from other crawlers.

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Six crater-shaped pistons develop 225 hp in the HD-21, 150 hp in the HD-16 . . . both at an easy 1825 rpm. Coupled with torque converter drive they provide plenty of rough dozing lugability . . . all the power you'll ever need.

These big Allis-Chalmers tractors are built for mighty tough service. Shock-absorbing all-steel main frame, durable double-reduction final drives, certified permanent lubrication of tapered roller bearing truck wheels, idlers and rollers, and extra tough track keep them going season after season with a minimum of maintenance. Your Allis-Chalmers construction machinery dealer will be glad to show you an HD-21 or HD-16 soon. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

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B. *RCV 8x16 units in a carburetor testing operation.*
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In a variety of applications Roots Vacuum Pumps deliver

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The high operating speeds of Roots-Connersville blowers for vacuum service result in lower horsepower requirements. Power savings of as much as 25% are possible. What is more, the simple, rugged rotary positive design of these vacuum pumps provides additional savings in initial cost, long-term investment, maintenance and floor space. These advantages are being demonstrated in a wide variety of mining, paper making, chemical processing, general manufacturing and testing operations.

Type RVS vacuum blowers are offered for efficient low volume service. Designed to handle capacities ranging from 30 cfm to 1,000 cfm, they can operate up to 20" Hg. vacuum in single stage construction.

Type RCV units are available for air and gas handling capacities from 500 to 13,000 cfm and are recommended for vacuums up to 17" Hg.

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Your nearest Roots-Connersville sales engineer can give you full details. Or write for Bulletin VP-158 (RCV) and S-RVS-159 (RVS).

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MINING engineering REPORTER

Mesabi, Reserve Mining Settle Disagreement

Negotiations have ended the dispute between Mesabi Iron Co. and Reserve Mining Co. involving the much-discussed question of profit or loss over Reserve's working of iron ore properties in Minnesota which it leased from Mesabi. The peace pact calls for: 1) Reserve to pay Mesabi a royalty of $1 per ton on all pellet concentrates produced and shipped after January 1, 1960 (based on an average natural iron content of 61 pct), 2) Reserve to assume all remaining pre-production expense, 3) Mesabi to drop claims for further payment for pellets produced prior to January 1st, and 4) Reserve to transfer to Mesabi all interest in the Mesabi shares it now holds and to pay Mesabi a cash sum of $400,000. A reduction in the royalty to Mesabi for pellet production beyond present plant capacity and up to a set maximum was also agreed on to encourage expansions at the Babbitt mine and the concentrator at Silver Bay.

Moa Bay Operations To Be Suspended

The nickel-cobalt mine and concentrator at Moa Bay, Cuba, will be shut down because of "a new Cuban mining law and other recent Cuban developments," announced Freeport Nickel Co., owner of the facility. Moa Bay has not yet reached full production and Freeport reports itself unable to obtain funds previously arranged for to complete construction. Major terms of the new Cuban law: a 5 pct levy on value of all minerals taken from the ground and one of 25 pct on exported ore. Freeport's efforts to negotiate apparently have met with no success.

First Southern Peru Copper Shipment

The first shipment of blister copper from Southern Peru Copper Corp.'s $235-million project at Ilo, Peru, has been unloaded at the American Smelting & Refining Co. refinery at Baltimore, Md. Production began January 1st at the billion-ton project, which is jointly owned by four companies. Controlling interest, or 57¾ pct of the stock, is held by Asarco. Cerro de Pasco and Phelps Dodge each hold 16 pct, and Newmont Mining holds 10¼ pct. The new smelter, on completion in May, will be producing 11,600 tons of blister copper a month.

Fleur de Lis Hits Bottom

Black Lake of Quebec is a lake no more. The efforts of Lake Asbestos of Quebec Ltd. and the dredge Fleur de Lis have combined to drain dry the one-time 500-acre lake, and its bottom has now been converted to a 100,000-ton-per-year open pit asbestos mine. The six-year Black Lake project involved removal of more than 31 million cu yd of overburden. The ore originally lay 560 ft below lake level.

New Asbestos Find

The Government of Quebec has announced the discovery of a 7-million-ton asbestos orebody in the Ungava area, between Cape Smith and Wakeham Bay. Ore quality is reported high, but the area's climate is difficult.

MINING engineering REPORTER

Coal Waste Research Plan Now Single Effort

General Dynamics Corp., which had been considering a joint program with Philadelphia & Reading Corp. to develop useful chemicals from coal waste, has decided to drop from sharing in the plan. Philadelphia & Reading promises definite plans shortly on its own program to make use of anthracite wastes. A subsidiary unit will be set up near Pottsville, Pa.

Pittsburgh Steel Buys New Ore Properties

Pittsburgh Steel Co. is bolstering its position in iron ore holdings by taking on three additional interests. In its biggest acquisition, Pittsburgh has purchased a partnership in an effort by several corporations to develop the open pit property of Wabush Iron Co. Ltd. in Newfoundland. The company will invest some $6 million, in anticipation of receiving 400,000 to 500,000 tons of ore annually when the mine starts output in 1965. Pittsburgh has also purchased complete ownership of Bennett Mining Co., an open pit Mesabi producer in which it previously owned part, and a 25-pct interest in Lake Mining Co., another firm on the Mesabi Range. The buying program pushes up the amount of ore the company will obtain from owned or partnership sources from 40 pct to 70 pct.

Semi-Taconite Pilot Plants

To investigate the commercial potential of Minnesota's soft, low grade semi-taconites, M. A. Hanna Co. and Oliver Iron Mining Div. of U. S. Steel Corp. are putting up two separate pilot plants in the western section of the Mesabi Range. The 10-tph Hanna plant, expected to cost almost $2 million, will be erected near Cooley, Minn. Oliver plans to set up a 5-tph facility at Coleraine, Minn. Both companies apparently are aiming at converting the non-magnetic ore to magnetic through roasting processes.

Aluminum Capacity Upped Again

The opening of new potline is increasing capacity of both Aluminum Co. of America and Reynolds Metals Co. Start-up of a sixth Alcoa line at its Point Comfort, Tex., smelter will raise the plant's output rate from 100,000 tons annually to 120,000 tons. Reynolds is putting on line the second of three units at its new plant at Massena, N. Y., adding about 33,000 tons a year to present production.

Four Consecutive Tunneling Records

Eimco Corp. reports the Australian subsidiary of Utah Construction Co. has established a new world record of 590 ft for one week of tunneling (6-day week, no overtime) using Eimco model 40H rock loaders. The contractor had set a series of prior records starting last September and topped each one successively four times. The previous high mark was 484 ft.

Nickel Use Climbing

H. J. Fraser, president of Falconbridge Nickel Mines Ltd., points out that world use of nickel is climbing at an average rate of 25 million lb annually. He looks to rising use of steel, with corresponding consumption of nickel in stainless types. Present nickel use totals about 2 lb per ton of steel, he said.

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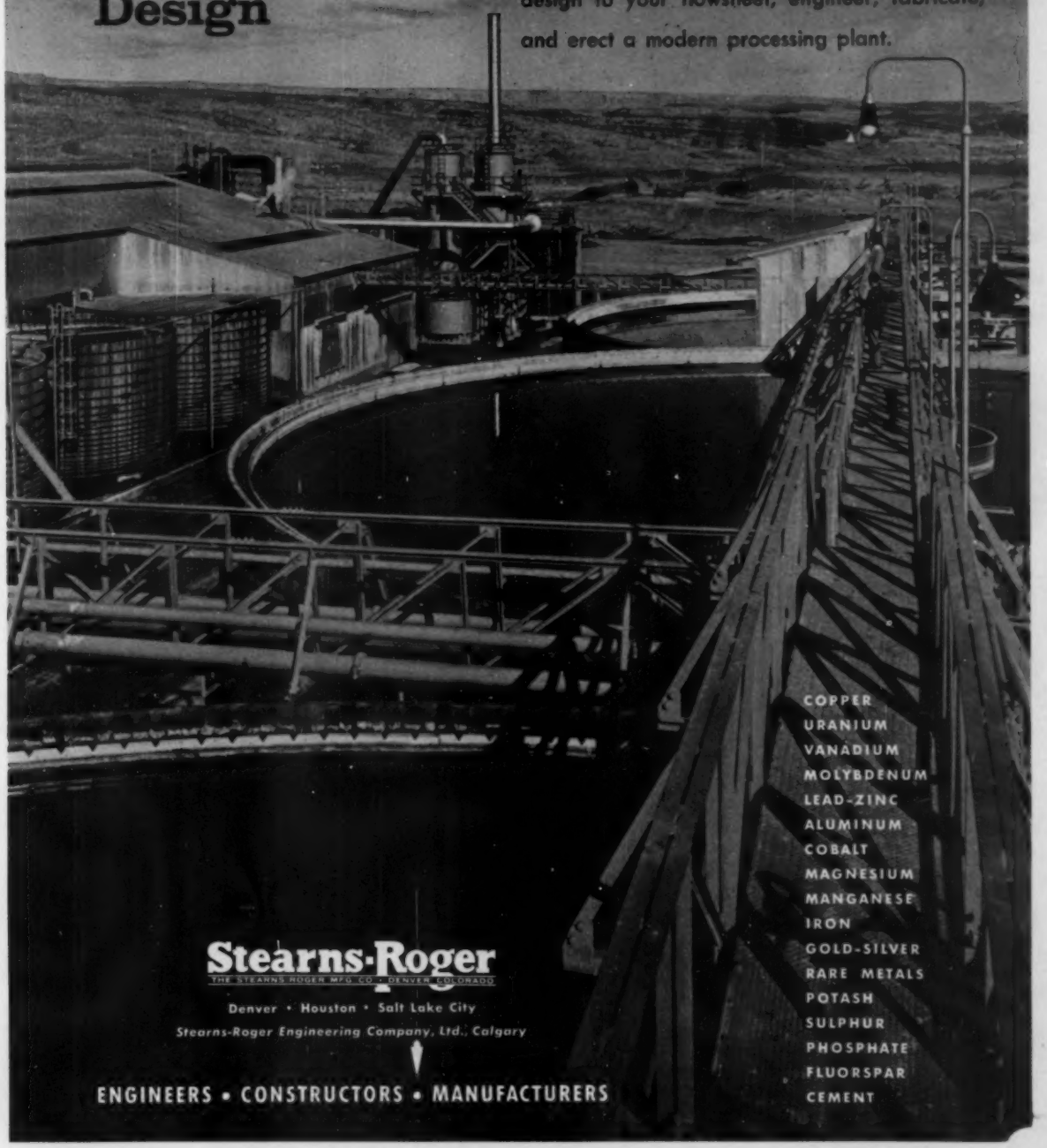
For progressive design, for professional engineering services, and for a profitable operating plant, Stearns-Roger is the logical one-source answer. Over 70 years experience in the design and construction of metallurgical, mineral and chemical beneficiation plants, small and large, assurance that for you, too, Stearns-Roger can design to your flowsheet, engineer, fabricate, and erect a modern processing plant.



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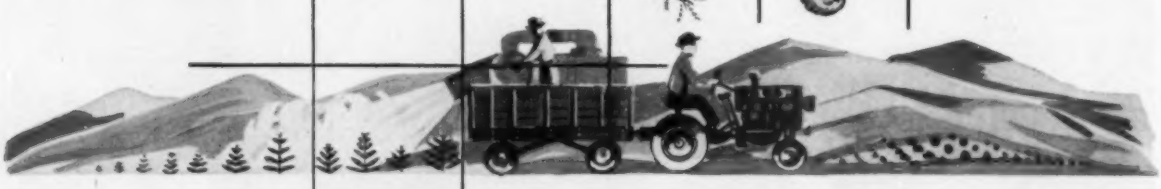

A recently compiled breakdown of Sulphur consumption in the United States, shows about 2% of the Sulphur goes into the manufacture of insecticides and fungicides.

Not much, perhaps, as tonnages go but no other use of Sulphur is more important with the possible exception of the 'wonder' drugs. It doesn't take much imagination to picture what would happen if the bugs and parasites were allowed to take over our crops and trees. Sulphur, along with other chemicals, is helping to protect our food supplies and foliage.

The role that TGS is playing in this constant fight against crop destruction is to see to it that the manufacturers of the insecticides and fungicides *always* have a ready supply of Sulphur, both solid and molten. This constant production and centralized distribution coupled with technical help is our contribution to industry.

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Coromant bits and steels have many other advantages, too: Better quality carbide (Sandvik is one of the largest manufacturers of carbide in the world)... better, more rigid steel...superior workmanship... all add up to above-average bit and rod life, up to double the footage between sharpenings, and straighter, cleaner holes.

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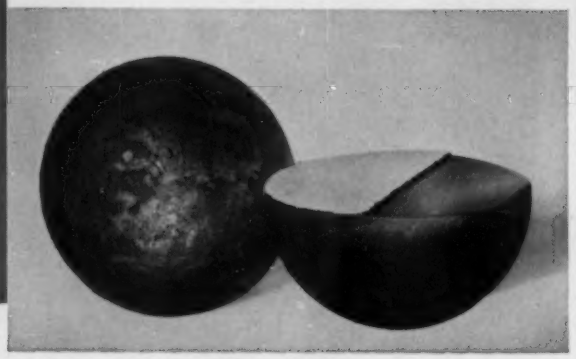

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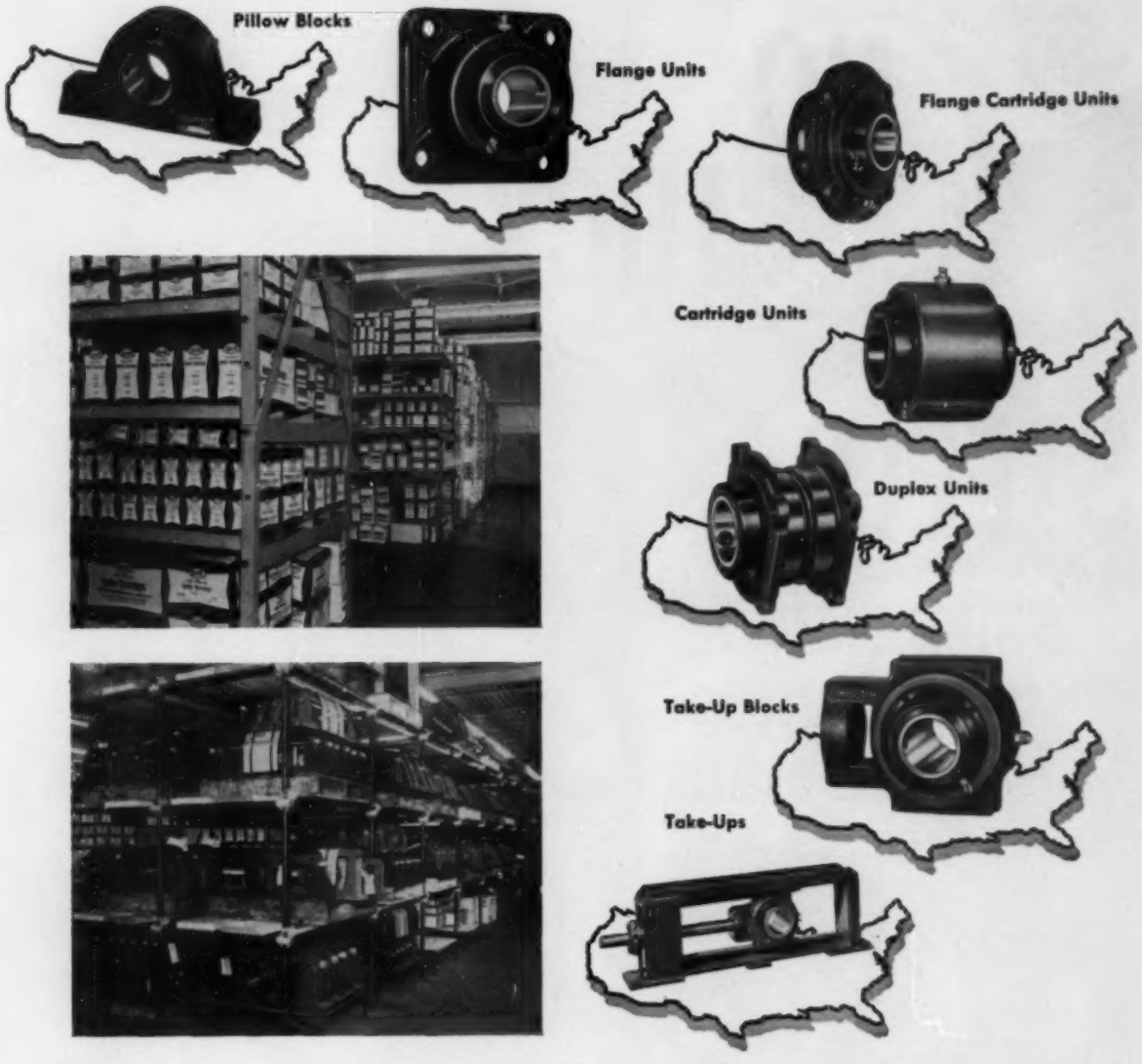

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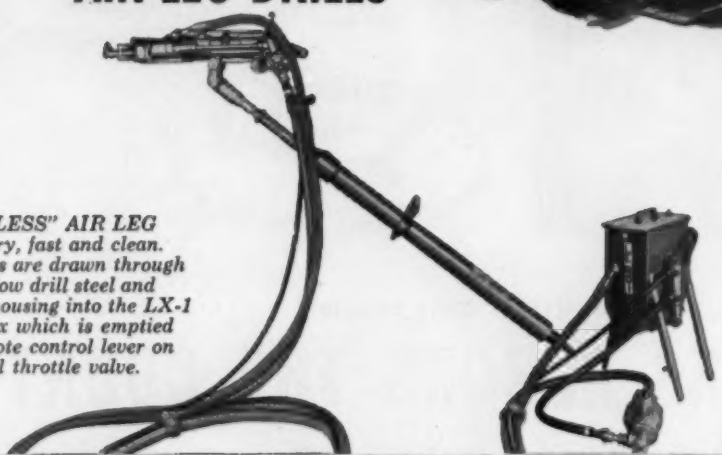


NEW "DUSTLESS" AIR LEG drills dry, fast and clean. Cuttings are drawn through the hollow drill steel and chuck housing into the LX-1 dust box which is emptied by remote control lever on the drill throttle valve.

Steels never stick when they're on the business end of the *new* Le Roi LLV Dust-Collecting Air Leg Drill. The dustless drill melts its way through the hardest rock — piles up more drilling footage with a lower dust count than was ever possible with wet drilling.

Dry, dustless drilling permits continuous ore sampling — saves every speck of precious ore. It eliminates the need and expense of water — does away with wet, dangerous conditions; sinking pillars; lost holes; water and muck haulage.

The LLV collects dust through the drill steel and exhausts it through the chuck housing — *not the machine!* It's ideal for mining or tunneling in hard rock — saves tools and operators.

Ask your Le Roi distributor for a demonstration. Or for more information, write to the Le Roi Division, Westinghouse Air Brake Co., Milwaukee 1, Wis.

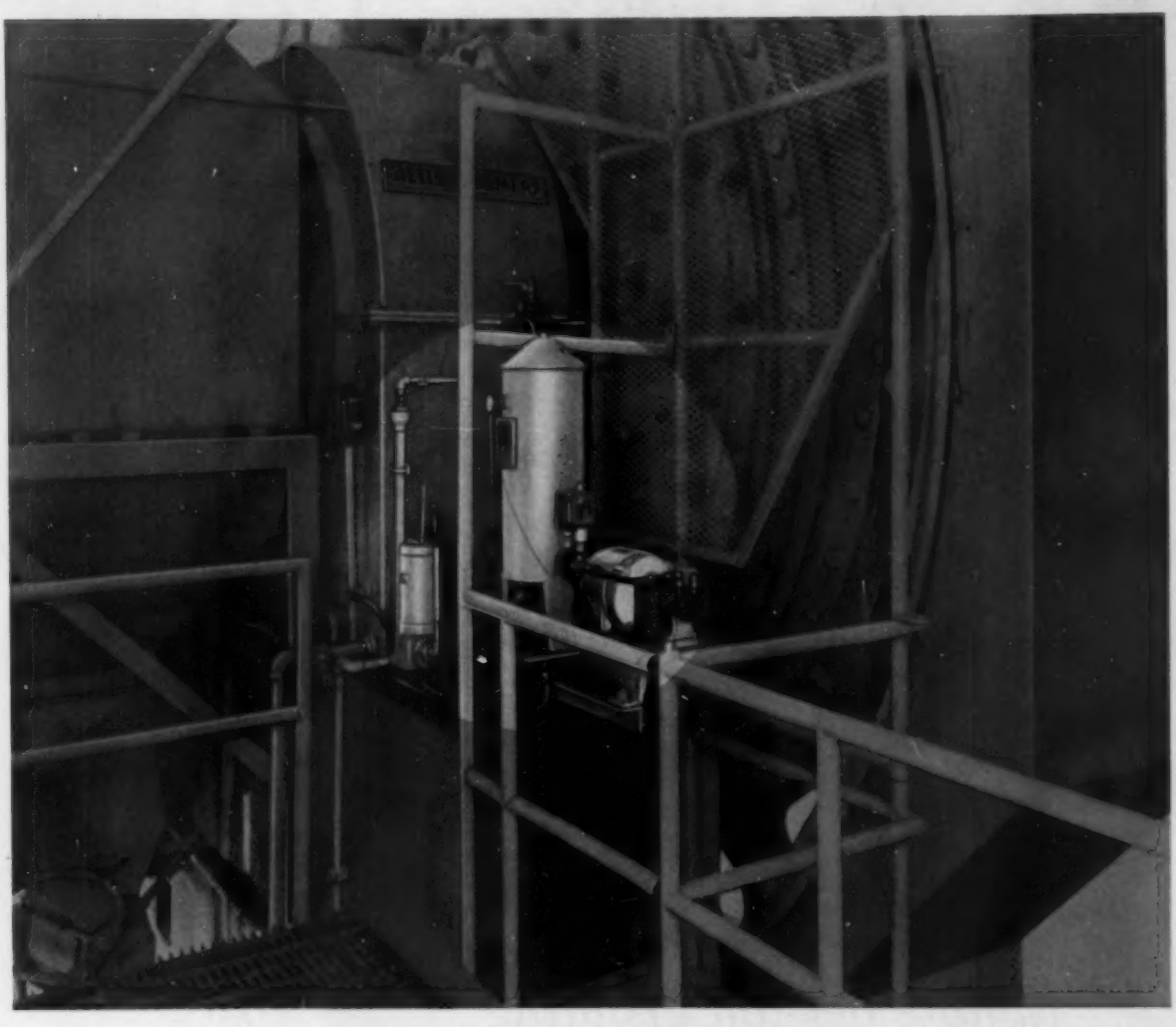
LE ROI NEWMATIC® AIR TOOLS

PORTABLE AND TRACTAIR® AIR COMPRESSORS • STATIONARY AIR COMPRESSORS • AIR TOOLS

AT-907

ALLIS-CHALMERS

A-1269



Floating start, ride and stop for big mills

New Lubritrol system provides constant lubrication for trunnion bearings

The new, bigger A-C grinding mills actually *float on oil.* Process industries are grinding out bigger profits because of *Lubritrol* constant lubrication system. No bearing-wearing starts. No dry sliding after shutdown. Less wasted horsepower. All functions of the *Lubritrol* system are automatic...controlled by foolproof pressure gauges and switches. The system is filtered to remove contaminants.

When you modernize your operation, check the benefits of an Allis-Chalmers grinding mill — the only mill that gives you the positive protection, the operating and maintenance economy of *Lubritrol* constant lubrication. *See your A-C representative, or write* **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin. In Canada, write Canadian Allis-Chalmers Ltd., Box 37, Montreal, Quebec.* Lubritrol is an Allis-Chalmers trademark.

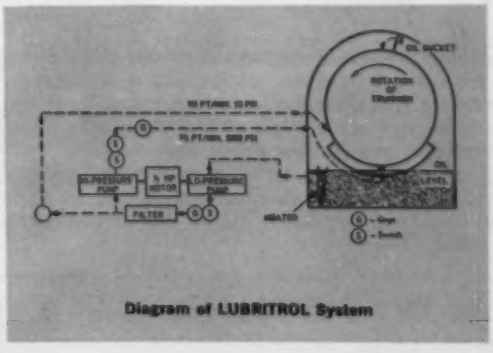


Diagram of LUBRITROL System

NACO ALLOY BALLS

through closer metallurgical control

ROCKWELL	BRINELL
63	710
61	670
59	638
57	601
55	555
53	534
51	495
49	477
47	444
45	429

1½ 1⅛ ¾ ⅜

Distance from surface—inches

tumble per-ton grinding *costs*

Through precise laboratory controls of the elements in steel making — from spectrographic analysis through final heat treating — Naco Grinding Balls possess the correct structure and hardness for maximum impact absorption and wearing qualities. Structurally, Naco Grinding Balls have a grain akin to tool steel — tough, hard and rugged. Laboratory tests show remarkable uniformity in solidity and controlled hardness holding to desired depth. Every day more mill operators are tumbling to the cost-saving advantages of Naco Grinding Balls.

CAPITOL FOUNDRY DIVISION
POST OFFICE BOX 750
PHOENIX, ARIZONA

NATIONAL MALLEABLE and STEEL **CASTINGS COMPANY**

General Offices • Cleveland 6, Ohio

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*Galigher products-at work. The complete installation at El Salvador includes 692 AGITAIR cells, 30 SAMPLERS and 40 VACSEAL PUMPS.

Congratulations, ANACONDA, on the successful launching of the great EL SALVADOR project!

The Galigher Company is *most happy to extend best wishes* to the Anaconda Company on the occasion of its highly successful start at El Salvador.

Our stake in this *fine success is obvious:* Contributing to the plant's smooth and profitable operation are three widely known and used Galigher products — VACSEAL Pumps in materials handling; GEARY-JENNINGS Samplers in control processes; and AGITAIR® Flotation in the metallurgy of recovery.

It is *especially gratifying* to know that this endorsement of Galigher equipment stems from the fact that Anaconda has successfully used these same products in several of its other operations.

GALIGHER
CONSULTATION • ORE TESTING • PLANT DESIGN

Leaders in Experience and Service

AP—505

GALIGHER PRODUCTS: AGITAIR® Flotation Machine, VACSEAL Pump, Geary-Jennings Sampler, Acid-proof Sump Pump, Geary Reagent Feeder, Laboratory AGITAIR® Flotation Machine, Laboratory Pressure Filter, Laboratory Ball Mill, Rubber Lined and Covered Products, Plastic Fabrication.

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Traylor-Made . . . means rugged dependability in heavy machinery. 60 years of industrial engineering experience goes into our ROTARY KILNS, PRIMARY and SECONDARY GYRATORY CRUSHERS, JAW CRUSHERS, APRON FEEDERS, BALL MILLS.

write for bulletins, giving complete information.

TRAYLOR ENGINEERING & MANUFACTURING
DIVISION OF FULLER COMPANY
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TGA1

CYANAMID

Reagent News

"ore-dressing ideas you can use"

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Cyanidation Process Chemicals
Flotation Reagents
Flocculating Agents
Film Forming Agents
Surface Active Agents

High Explosives
Permissibles
Seismograph Explosives
Blasting Agents
Blasting Caps
Electric Blasting Caps
Blasting Accessories

AEROSOL® OT Surface Active Agent improves acid leaching operations

Recent plant experience in U. S. and Canadian uranium acid leaching operations shows that the continuous addition of a small amount of AEROSOL OT-75% saves many times its small cost. One of the most powerful wetting agents, AEROSOL OT addition to the leach circuit can:

1. **Reduce average tailings assays by smoothing out fluctuations, particularly where leach retention times are a problem.**
2. **Cut acid consumption by improving the wetting and penetrating action of the leach solution.**
3. **Improve filtration and thickening operations.**

Here is the box score on several of these trials:

MILL A:

Addition of 0.1 lb/ton AEROSOL OT-75% costing 5¢ per ton of ore treated decreased acid consumption and reduced acid costs by about 30¢ per ton without any change in tailings assay.

In addition, residual AEROSOL OT is carried through to the thickeners clearing persistent foam from the tops of the thickeners. Efficiency of the solvent extraction operation is unchanged by the AEROSOL OT addition.

MILL B:

Addition of 0.13 lb. AEROSOL OT-75% increases extraction by 30 to 40¢ worth of U_3O_8 per ton of ore milled. Acid consumption has been reduced 30 lb. per ton of ore milled (from 140 lb/ton to 110 lb/ton) with attendent savings on lime for neutralization. Total savings are estimated to be 57¢ per ton of ore treated with AEROSOL OT cost of only 6 to 7¢ per ton. Tailings assay is unchanged; no adverse effects have been noted in the ion-exchange circuit.

MILL C:

Mill schedule calls for almost continuous repair work on the agitators in the two treatment lines, cutting retention time of ore in the leach circuit. This plant saves approximately $79,000 per year by adding 0.14 lb/ton AEROSOL OT-75% during periods when retention time in the leach circuit is shortened to permit the preventive maintenance work.

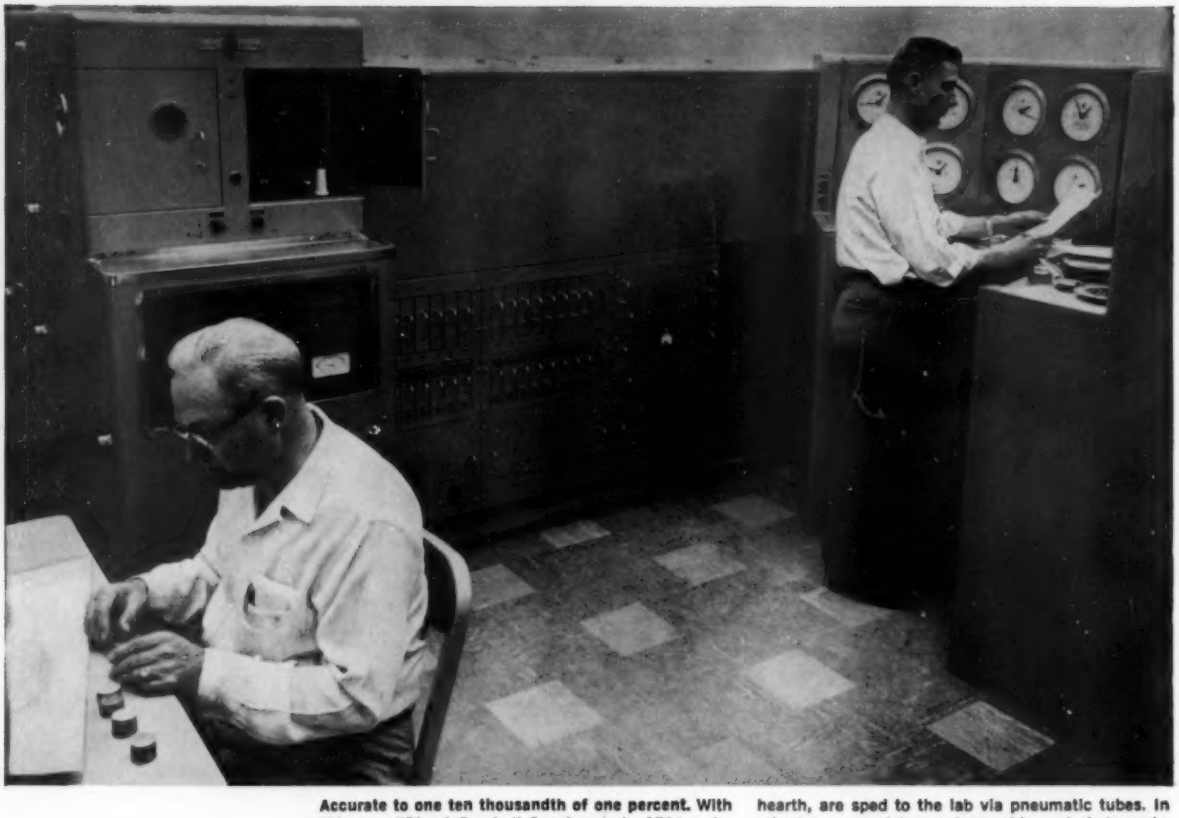
Laboratory and plant trials with AEROSOL OT-75% Surface Active Agent may show the way to savings at your acid leaching operation. In addition to uranium processing, AEROSOL OT-75% could also show benefit in acid leaching of copper and zinc ores, for example, as well as other related applications. AEROSOL OT-75% has also found wide application in the mining industry as a filtration aid for improving cake quality and reducing cake mosture.

Send for your sample of AEROSOL OT-75% today.

AMERICAN CYANAMID COMPANY
EXPLOSIVES AND MINING CHEMICALS DEPARTMENT

CYANAMID INTERNATIONAL — *Mining Chemicals Department*
Cable Address: — Cyanamid, New York

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.



Accurate to one ten thousandth of one percent. With this new "Direct Reader" Spectrograph, CF&I maintains extraordinary control over each melt of steel. Samples, taken from the blast furnace or open hearth, are sped to the lab via pneumatic tubes. In minutes, a complete spectrographic analysis is ready. This "controlled chemistry" means Grinding Balls and Rods that wear longer, grind more efficiently.

What CONTROLLED CHEMISTRY means in CF&I Grinding Balls and Rods

CF&I takes great care in the selection of steels used in its grinding balls and rods. For example, each size ball from the smallest to the largest (¾" to 5" diameter) must have the proper composition to give the best balance between hardness and toughness. CF&I's modern spectrographic equipment assures you balls with the correct chemistry in relation to their size. In fact, CF&I uses different steels, depending on the ball size required. This chemical control pays off in your mill because CF&I balls have greater resistance to abrasion, withstand impact, and grind at lower cost.

In grinding rods, CF&I observes similar standards. Special analyses of high carbon steels are hot-rolled and machine-straightened to close tolerances, from 1½" to 4" diameter in whatever lengths ordered. CF&I's controlled chemistry techniques result in grinding rods that have excellent wearing properties, resisting bending or premature breakage.

For the complete story on the advantages of CF&I Grinding Balls and Rods, get in touch with your local CF&I Sales Office.

Other CF&I Steel Products for The Mining Industry

CF&I Mine Rail and Accessories • CF&I Rock Bolts • Realock Metallic Fabric
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CF&I STEEL

MINING PRODUCTS

THE COLORADO FUEL AND IRON CORPORATION

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In the West: **THE COLORADO FUEL AND IRON CORPORATION**—Albuquerque • Amarillo • Billings • Boise • Butte • Denver • El Paso • Ft. Worth • Houston Kansas City • Lincoln • Los Angeles • Oakland • Oklahoma City • Phoenix • Portland • Pueblo • Salt Lake City • San Leandro • Seattle • Spokane • Wichita
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Economical underground bulldozing with the...

EIMCO 630

Here's a heavy-duty crawler, sized to work in low headroom, able to operate fast and easy in tight spots, powered to provide ample push for moving tough material. The EIMCO 630 BULLDOZER makes it practical to bulldoze underground, often the most efficient way to move earth and material.

Eimco 630 Dozers are pushing material to a raise from low headroom flat headed stopes, level blasted muck in headings, clean various types of inverts; are grading and producing with mobility and reliability, in many other ways. It works where a slusher cannot be rigged, removes material around pillars fast and economically.

If your job calls for a fast LOADER, the EIMCO 630 EXCAVATOR (inset) is the answer. Extraordinary digging action, overhead discharge and easy operation speed up handling of heavy, hard-to-dig material. Versatile and fast, you'll find scores of other uses for this great production tool.

BOTH THE EIMCO 630 BULLDOZER AND THE EXCAVATOR ARE AVAILABLE WITH AIR OR ELECTRIC (A.C.) POWER.

Get all the facts! There's an Eimco Dealer or Branch near you, ready and able to serve you, or write The Eimco Corporation, P. O. Box 300, Salt Lake City 10, Utah, U.S.A.

"ADVANCED ENGINEERING AND QUALITY CRAFTSMANSHIP SINCE 1884"

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MINING EQUIPMENT DIVISION

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B - 552

FROM THE BRITTLE COLD OF MINNESOTA'S MESABI RANGE
TO THE SOFTENING HEAT OF FLORIDA'S PHOSPHATE MINES—

Anaconda's new all-butyl Shovel Cable passes every life test

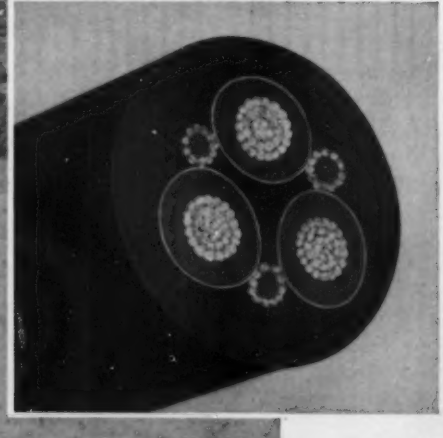
Heat, cold, kinks, even runovers and rock falls couldn't knock out this new shovel cable during months and months of torture-testing around the country.

That's because its new all-butyl *insulation* and *jacket* make it the toughest shovel cable you can buy. And—one of the most economical over the long haul. Anaconda's new process butyl—as an insulation—has proved its ability to take pinching, crushing and the effects of moisture and ozone in many fields—from extra-high-voltage power cable to surface mining. And now it's available to you as a *jacket* in Anaconda's new shovel-cable construction.

Because of its superb service record, the inner construction of this new cable remains the same. For example, you still get Anaconda's patented rubber-core grounding conductors which minimize wire breaking and offer greater ground protection. Also included are special shields of copper cross-braided with cotton—a construction which makes the braided shield lie flatter and eliminates chafing. In addition, this feature makes for much easier and faster splicing. Both electrically and mechanically, Anaconda shields are superior to all-metal construction.

Only Anaconda offers you this job-tested shovel cable with all these construction extras in a proven design. Add up the features—they mean extra cable life and dollar savings.

So, call the Man from Anaconda and ask him about the new Anaconda all-butyl Shovel Cable. Or write: The Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.



ASK THE MAN FROM

ANACONDA®

ABOUT THE ALL-BUTYL SHOVEL CABLE

Another New Product From Anaconda's Rubber Cable Center

Note the heavy-duty weather-resistant butyl jacket—the rubber core grounding wires—also see how the ground wires make constant contact with conductor shields.

WHAT WILL THE NEW BUILDING COST?

Expenditures:

To the Turner Construction Co. for erection	$8,042,000
Cost of the site, 1st Ave. 47th to 48th Sts. (United Nations Plaza)	2,800,000
Architect's fee	490,000
Necessary non-society equipment to put the building into operation	209,000
Interest on necessary short-term borrowing to meet costs until pledges mature	120,000
Cost of industry and member fund-raising activities, recording and collecting pledges	457,000
Legal fees	145,000
Contingencies	300,000
Total	$12,563,000

Income:

Industrial companies' gifts	$5,400,000
Member gifts from societies to be in the building	3,800,000
Sale of the present building	1,700,000
From depreciation fund, United Engineering Trustees (original four Founder Societies)	1,600,000
From AIChE, as an additional participant in the ownership by the Founder Societies	60,000
Total	$12,560,000

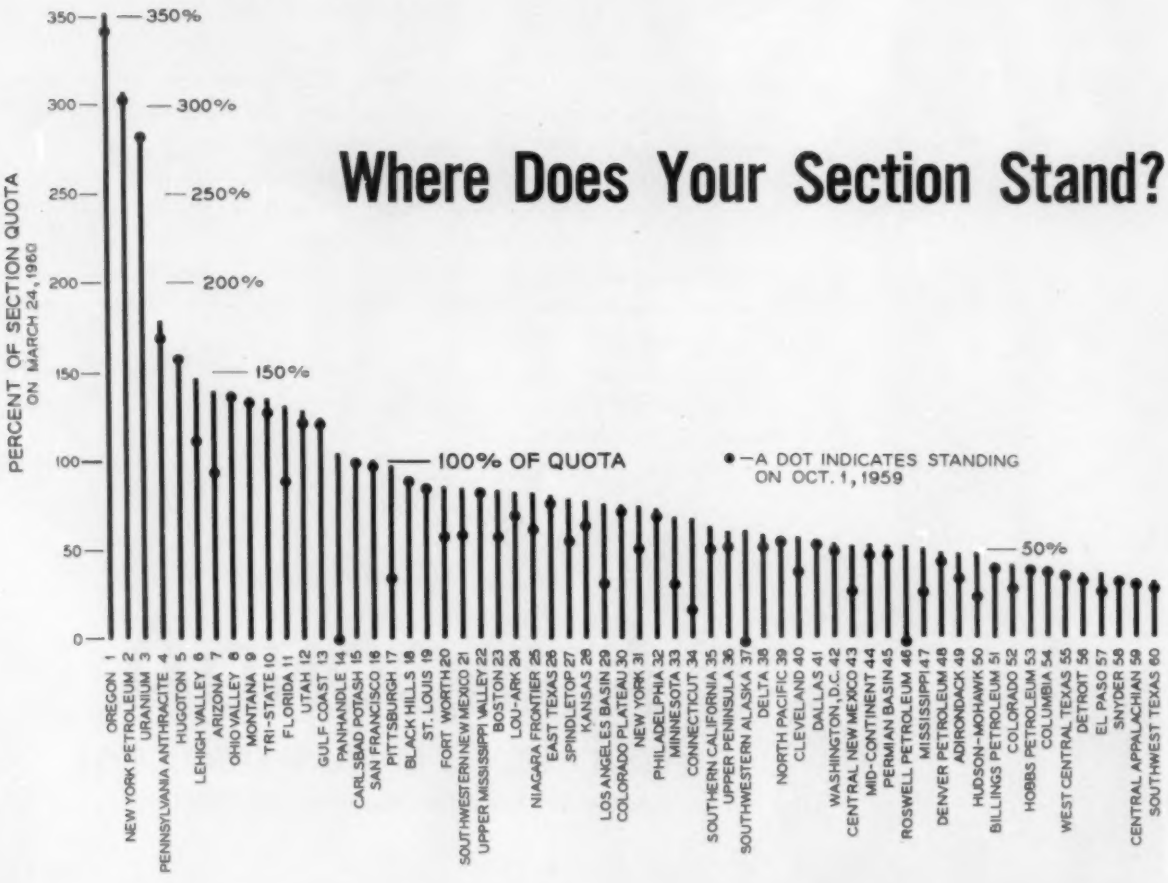
Are Our Faces Red!

Do we want other Engineers to think we (AIME) are Second Class? Twenty-two pct of us have already said NO. Most of the other 78 pct have not been asked personally to contribute. OK—HERE IT IS—Our building is going up but we need a little more money to pay for it. Mining and metallurgical members that have pledged have averaged $76, although the median gift is somewhat less.

Get in touch with your Local Section officers if they have not already

UNITED ENGINEERING CENTER BUILDING FUND CAMPAIGN

Where Does Your Section Stand?



approached you. If you live abroad and have no Local Section send your pledge or contribution direct to the AIME Secretary's office, 29 W. 39th St., New York 18.

Where Does Your Section Stand?

Quotas were set for each Local Section—based 1) on the fact that AIME's share in the Member-Gifts Campaign is $500,000, and 2) on the relative membership of the Local Section. The New York Section is asked to meet $150,000 of this, or $96 per member. The Petroleum Society has agreed to raise an equal amount. This leaves $200,000 to come from mining and metals members in Local Sections outside of New York, or an average of approximately $13 per member.

On the first of April 1960, 15 Local Sections had met or surpassed their goals, as the chart shows. Of these 15, Lehigh Valley, Arizona, Florida, and Panhandle have done much of their work in the last six months. Others that got off to a slow start but have made rapid progress are Pittsburgh, Los Angeles Basin, Connecticut, Southwestern Alaska, Central New Mexico, and Roswell.

It is not too late for the laggard Sections to start NOW. Pledges can still be made for the next three years—1960, 1961, and 1962.

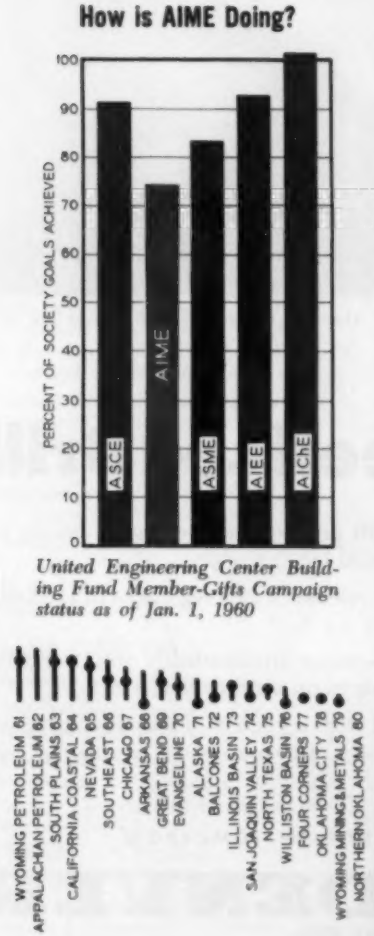
What Will the New Building Cost?

At the meeting of the national Member-Gifts committee for the United Engineering Center on Feb. 23, 1960, William Thompson, chairman of the Real Estate Committee of United Engineering Trustees, presented a statement of the expected income and expenditures for the construction of the new building—see the table, left.

AIME vs the Other Societies

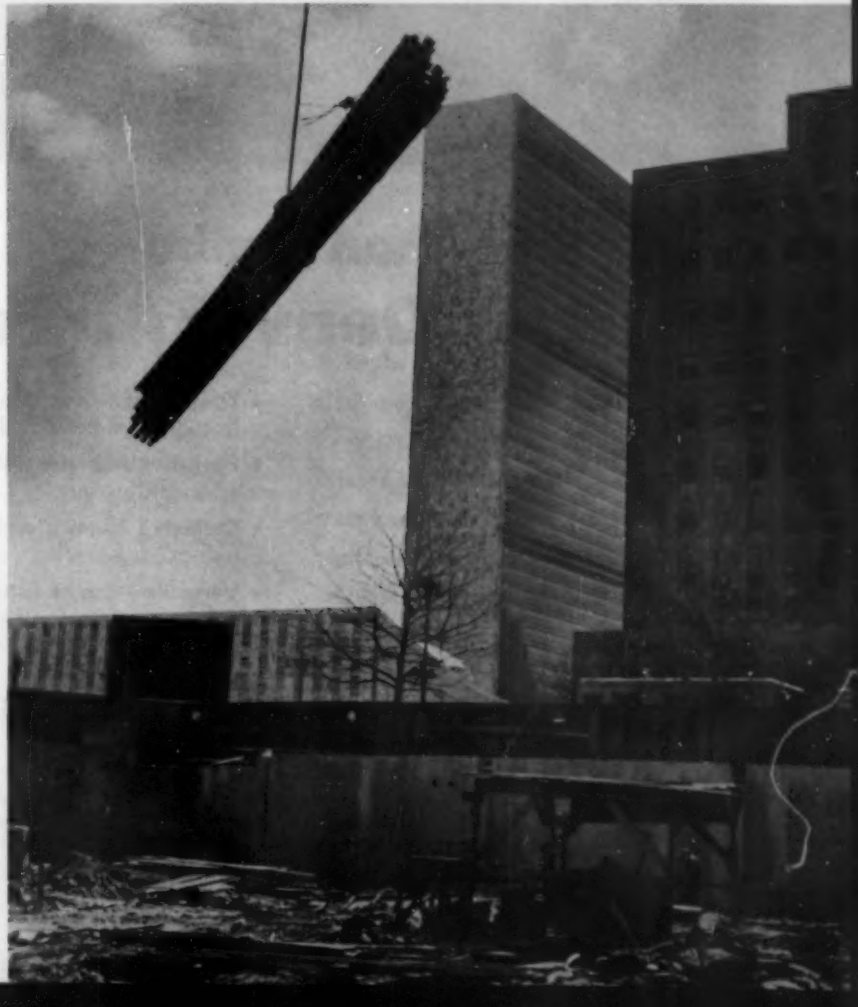
AIME lags behind the other societies in achieving its quota, but there is no reason to think that our members are less inclined to pledge funds for their new headquarters than are the members of other societies. The amount pledged per member has been greater for AIME than in any other society but the number of members who have pledged is relatively less.

Although three-year pledges were provided for in the Member-Gifts campaign, many members paid in full immediately, so 71 pct of all pledges had been paid by Feb. 23, 1960. Cancellation of pledges because of death or other good cause has been nominal.



United Engineering Center Building Fund Member-Gifts Campaign status as of Jan. 1, 1960

Steel piling rods hover over site just before being dropped to the excavation they will help reinforce. View is southeast toward the corner of UN plaza and 47th St. The UN and Carnegie Building are in the background, right and center.



Gardner-Denver FL58 Air Feed Leg Drill

A one-man jumbo—
Gardner-Denver Air Feed Leg Drill

Gardner-Denver Air Feed Leg drills hit hard . . . keep hole production up and costs down. Two drill bore sizes to choose from: $2\frac{1}{2}''$ and $2\frac{5}{8}''$. Feed travel from 24″ to 60″. Ask your Gardner-Denver mining specialist for details.

Write for bulletin.

- **Easy to use**—controls all grouped on back head. Single air line supplies both drill and leg.
- **Push-button bleed**—air release in feed leg backs drill off fast after drilling out.
- **Exclusive water gland**—water automatically goes to bit before drilling starts . . . stays on until drilling stops.
- **Versatile**—can be fitted with a variety of legs, including telescopic models. Drill easily removed for use as sinker.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

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MINING engineering **DRIFT**

ANACONDA'S EL SALVADOR DEVELOPMENT

It has been eight years since MINING ENGINEERING published a special issue about one of Anaconda's operations, the last one having been about the sulfide plant expansion at the biggest of copper deposits, Chuquicamata. There is great contrast in the type of operation in the two mines. El Salvador is comparatively high grade; operations are underground; and the mine, mill, and townsite are all brand new.

In contrast, Chuquicamata is comparatively low grade and open pit. An operation which has grown over many years, the sulfide plant in 1952 was only another stage in the life of one of the world's great mines. This issue salutes the addition of El Salvador to that select list.

The scope of both these operations provides an indication of the breadth of things with which mine management must concern itself, particularly in remote locations. Not only must there be provision for people to live, but there must be water to drink and to mine and mill with; power must be generated and transportation provided by air, rail, and road. These vital operations, auxiliary to actual mining and milling of ore, are detailed in the last third of the articles in this issue.

The engineering job revealed in the design and construction articles is most illuminating. The exposition of the alternate solutions that were considered before the final choice is as interesting in some cases as the description of the actual plan followed. The overall plan displays a balance in building for years of operation while avoiding details unnecessary to function. One might read the article on the crushing plant design as an object lesson in providing flexibility while discarding the unessential.

MINING ENGINEERING is grateful for the interest and efforts of the company officials who made the issue possible—men such as Charles M. Brinckerhoff, President of The Anaconda Co.; Wilbur Jurden, President of Anaconda-Jurden Associates; Vincent D. Perry, Vice President and Chief Geologist of The Anaconda Co.; and the man directly in charge of El Salvador operations, Norbert F. Koepel, Vice President of Chile Exploration Co. and Andes Copper Mining Co.

In particular, the staff wishes to offer thanks for the painstaking efforts of A. D. Rood, Assistant to the Vice President of Chile Exploration Co. and Andes Copper Mining Co., who gathered all the material for the issue. He personally co-ordinated the efforts of the various authors and requests from the editorial staff, following through at every stage and checking the hundreds of facts and details necessary.—*Rixford A. Beals*

The 1959 Index—Publication of the index to material in MINING ENGINEERING during 1959 has been delayed pending decisions on the status of the 1959 bound *Transactions* of the Society of Mining Engineers of AIME. It has been decided to publish this volume in the format used in previous years; it will contain *Transactions* papers published in MINING ENGINEERING in the 1959 issues. Therefore, the 1959 magazine index will appear in the June 1960 issue.

REQUIREMENTS BACKED BY RESEARCH

Creative research is working for you today at Halliburton! In a continuing program of creative research and development, new and better grouting materials and placement techniques have been and are being introduced by Halliburton to make pressure grouting more efficient and more effective than ever before. Halliburton can meet your grouting needs with:

MEN

. . . in the field – in the laboratory – on the job. Using their extensive knowledge, gained by technical training and sub-surface experience, to help you obtain better results with the most advanced techniques and equipment.

EQUIPMENT

. . . *job proven* for dependable and convenient metering, mixing and displacement of grouting materials.

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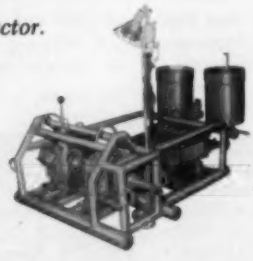
. . . in the widest selection of chemicals and cements available. *Chemical Grouts* for placement in a single operation – designed for more thorough setting throughout the permeable zones than with chemical-plus-catalyst, two-step methods. *Cement Grouts* designed for continuous placement in connection with consolidation and/or plugging of permeable formations. Admixes, retarders and accelerators are available for helping to provide greater control in setting characteristics and times in various formations.

Call your nearest Halliburton Pressure Grouting Service Division Office and see how this unbeatable MEN-EQUIPMENT-MATERIALS combination . . . backed by the most modern research facilities . . . can help provide you with *full-scope* service in the field of grouting.

Write today for your copy of the new "Halliburton Pressure Grouting Service" Brochure No. PGS-0002.

Halliburton is financially able to perform any size grouting job as a prime or sub-contractor.



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EL SALVADOR

MINING ENGINEERING *presents a special report on Anaconda's newest property—the largest new underground mine in recent years.*

- **Discovery**
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EL SALVADOR

By CLYDE E. WEED
Chairman of the Board,
The Anaconda Co.

For more than 100 years, the Republic of Chile has been one of the leading copper-producing countries of the world. Between 1877 and 1880 Chile accounted for over 50 pct of total world copper production. Today it has the world's largest known reserves of copper ore and a capability of producing over 600,000 tons per year. This capacity can and will be increased as the world demand for copper grows steadily during the remaining years of this century.

The Potrerillos mine of Andes Copper Mining Co., a subsidiary of The Anaconda Co., was developed in the rugged, high Cordilleras in the early 1920's, and the townsite, concentrator, leaching plants, smelter, railroad, power and port facilities were completed so that it came into full production in 1927. Since then and until the closing of the mine in June of last year, 1,762,192 tons of copper were produced.

Over the past ten years it had become increasingly evident that the Potrerillos mine would be economically depleted before the year 1960. With visions of a ghost camp in prospect at Potrerillos and its attendant depressing effects upon Atacama Province, Chile and its people, and the losses, hardships and heartbreak incident thereto, The Anaconda Co. from its far-flung operations marshalled its technical personnel, physical assets, and capital in a concerted, accelerated effort to find and develop a copper mine tributary to the Potrerillos operations. This exploration program resulted in the discovery of El Salvador. Finding and developing this mine, and the construction of a complete mining plant and concentrator, together with a modern townsite, public facilities and necessary utilities, is an engineering miracle, the story of which we are pleased to publish in the series of technical papers which make up this special issue of MINING ENGINEERING.

The work to bring El Salvador into production last year, and to full production this year, represents the application of capital, technical skills, and modern specialized equipment, animated by the quality and willingness of Chilean workmen in converting El Salvador's immense natural resources into a great source of national wealth and well-being.

In connection with this enterprise, the contribution of the Chilean Government is acknowledged in establishing a sound, long-range policy governing the development of natural resources, an investment climate conducive to making large risk investments possible and a true democracy working its way toward a stabilized economy.

The design and methods adopted in this new mine, plant, and townsite reflect the wealth of operating experience, research, and engineering skills available to our South American subsidiaries and help to insure that Chilean copper will be pre-eminently competitive in world markets. I commend to your reading and study this latest saga of mining.

HISTORY OF EL SALVADOR DEVELOPMENT

by V. D. PERRY
Vice President and Chief Geologist,
The Anaconda Co.

Modern Anaconda-built roadway contrasts vividly with bare hills, deep canyons of Chilean Pampa.

The bare hills, the deep canyons and upland slopes of the Chilean Pampa reveal the geology of that region in unique detail. The isolated prominence of Indio Muerto Peak, its significantly dissected sides, its variegated coloring are all surficial features attracting attention to the site of El Salvador mine.

There is no reliable information to explain the few shallow pits and shafts and the turquoise diggings that may go back to early day prospecting in Chile and to Inca or pre-Inca times. Primitive stone hammers and other artifacts, found in a nearby Indian burial ground, testify to the antiquity of some of the workings.

EARLY OBSERVATIONS

Anaconda's interest, in terms of historical background, is quite recent. It dates from 1922 when, during the early days of development at Potrerillos, I. L. Greninger, then mine superintendent for Andes Copper Mining Co., described a prospect near Indio Muerto Mountain that showed evidence of copper mineralization. Known as the Camp area, it is 1½ m north of Indio Muerto Peak and Turquoise Gulch, under which El Salvador orebody was subsequently found. Greninger's letter stated that the Camp prospect, if located close to transportation, might be worth testing, but that the tonnage possibilities did not appear great enough at that time to warrant construction of transportation facilities.

In the following years of depressed copper prices, there was no interest in the district, and it was not until 1942 that a geological reconnaissance of part of the area was made by Walter March, then Chief Geologist for Chile Copper Co., E. F. Reed, Sam Watson, Jr., and Clifford Wendell, March's assistants. The examination did not fully cover Indio Muerto Peak, and there is no reference in their report to the Turquoise Gulch area. The report recommended further geological examination and the denouncement of claims to cover all mineralized outcrops.

In February 1944, Reno H. Sales, Chief Geologist of Anaconda, March, Wendell and the writer, made a brief visit to the Camp area. Then, in 1945, Anaconda geologists R. B. Mulchay and E. C. Stephens, and Watson of the Andes staff, did further geologic mapping and recommended exploration of the Camp area prospect.

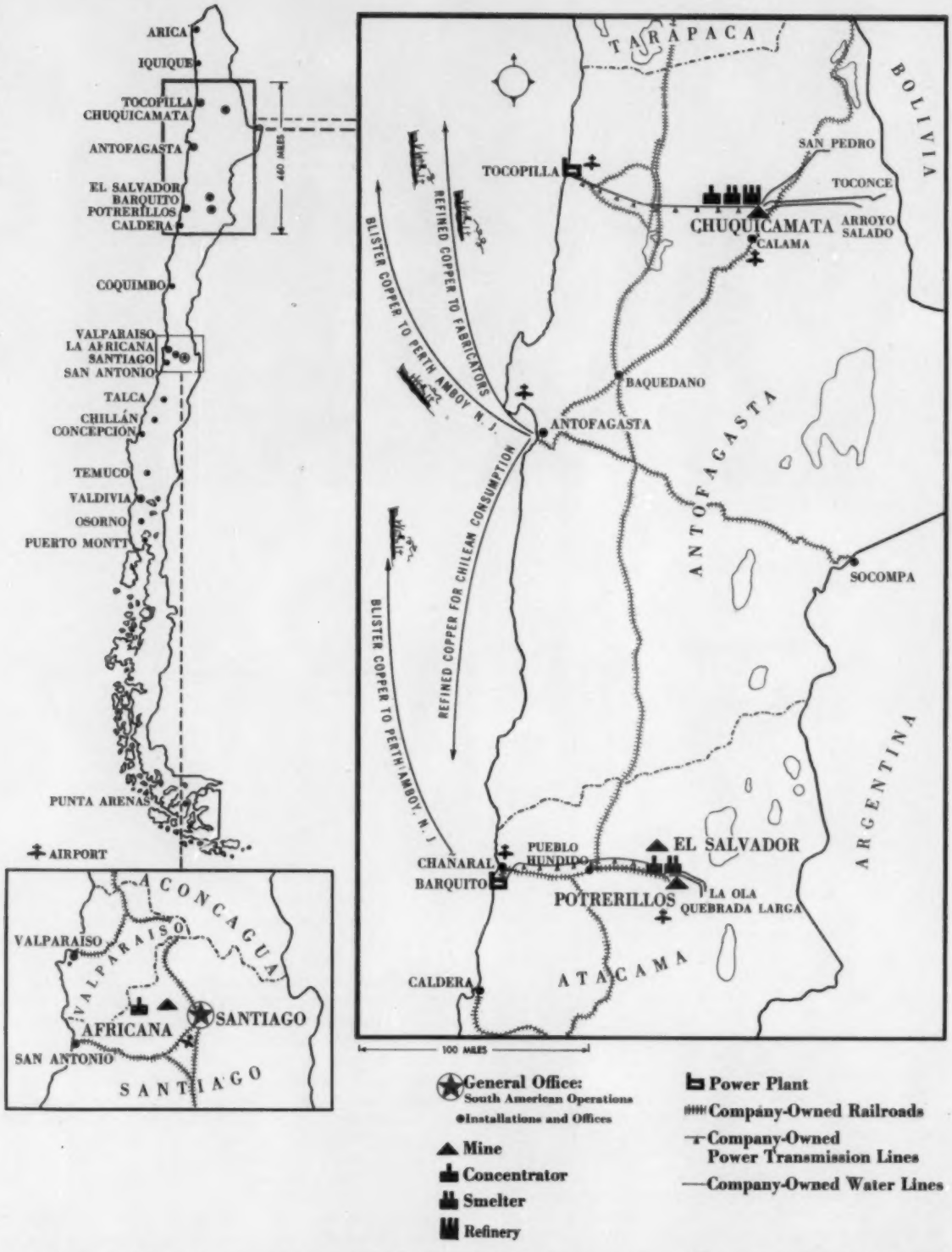
THE KEY YEAR

Starting about 1950, it became evident that many influential Chileans in and out of government were thinking constructively about long-range and far-sighted policies for developing their country's natural resources. Encouraged by this progressive attitude, Anaconda began an intensive exploration effort directed locally to replace the rapidly depleting Potrerillos ore reserves and, generally, to increase Anaconda's participation in Chile's copper production. As part of this program the writer returned to the district in February 1950, accompanied by W. T. Swensen and E. H. Brinley, Andes Company geologists; made a one-day reconnaissance up the northwesterly slopes of Indio Muerto and into the cirque-like amphitheater at the head of Turquoise Gulch. Impressed with the geological structure, rock relations and the character of mineralization and alteration in the leached capping, he made a second trip a few days later, accompanied by William Swayne, Anaconda exploration geologist in Chile.

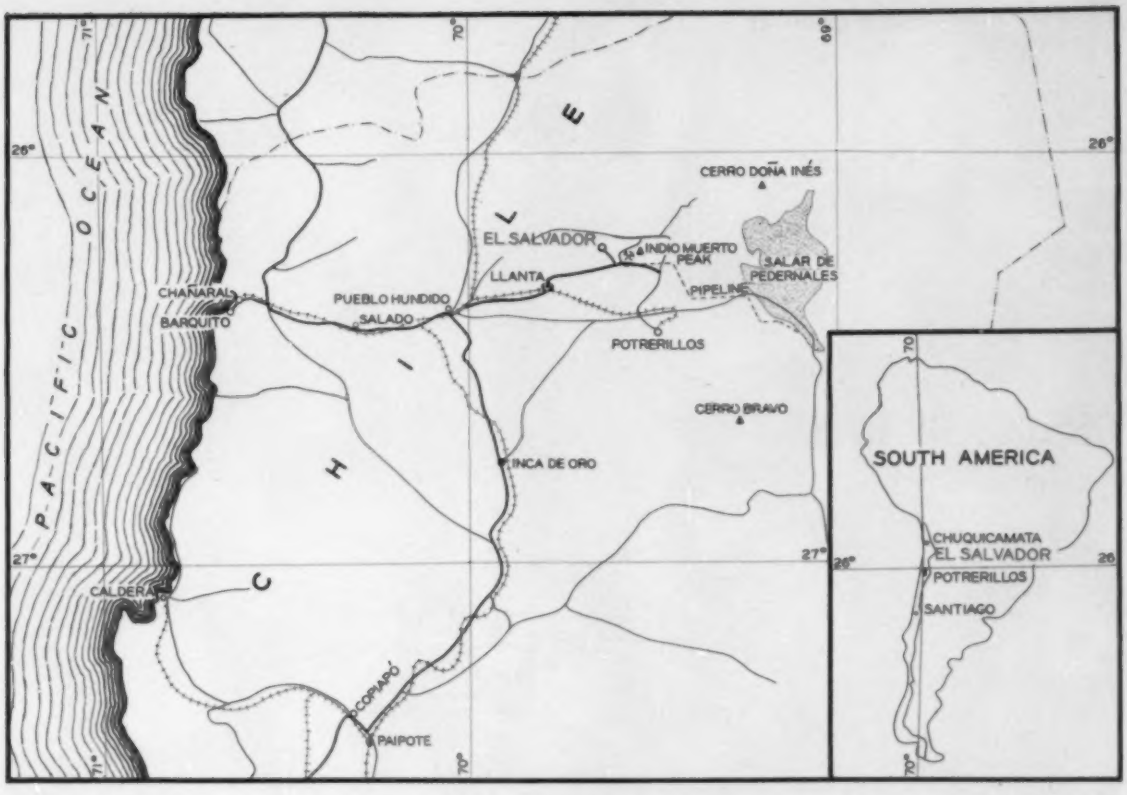
THE FIRST PHASE

A letter by the writer, dated April 28, 1950, to

ANACONDA'S OPERATIONS IN CHILE



Operations of Chile Exploration Co. are located at Chuquicamata. Power is generated at Tocopilla. Operations of Andes Copper Mining Co. are located at Potrerillos and at El Salvador. Power is generated at Barquito. La Africana mine of the Santiago Mining Co. is located near the city of Santiago.



C. E. Weed, then Vice President of Anaconda, stressed the theory that the primary mineralizing solutions associated with the Indio Muerto or Turquoise Gulch porphyry carried appreciable amounts of copper within a structural focus of intrusion and fracturing, and that the outcrops of thoroughly leached, barren capping in the vicinity of Turquoise Gulch indicated an underlying zone of secondary chalcocite enrichment. The letter recommended aggressive action in claim denouncement, exploration and development of the prospect. Under the writer's direction, Swayne was assigned the job of surveying and mapping the geology. His enthusiasm and persistence in the face of difficult field conditions were vital factors in constructing an accurate map of the district and in assisting in the selection of initial drilling targets. He was aided in his mapping by John Bain of the Andes' staff and was helped materially by laboratory analyses of systematic rock collections which were studied in the Butte Geological Laboratory by Charles Meyer, then in charge of Anaconda geological research.

EXPLORATION BEGINS

A detailed report on the district was submitted in May 1951 and, on the basis of the report, plans for exploration were made. Swayne, with the help of an assistant, Hans Langerfeldt, organized, directed, and serviced the drilling job. The first two holes in the vicinity of Turquoise Gulch disclosed thin sections of chalcocite mineralization, and then the drilling site was moved to the Camp area, where several holes developed a relatively small tonnage of primary chalcopyrite ore.

Steady progress was made despite extremely difficult operating conditions, which included rugged terrain, lack of water supply and absence of roads. In April 1954 drills were moved back into Turquoise Gulch, and it was then that important high-grade, secondary chalcocite was cut below the barren oxidized outcrops of the Gulch. Results were so encouraging that it was evident a major discovery had been made.

THE PROJECT TAKES SHAPE

Events followed in rapid succession, and orders were given by R. S. Newlin, Anaconda Vice President—Mining, to speed up development so that the El Salvador mine could be brought into production at an early date. The program was placed under the direction of C. M. Brinckerhoff, then Vice President of the Chile and Andes companies, and under the immediate supervision of N. F. Koepel, then General Manager, and H. E. Robbins, General Superintendent of the Andes Co. The geological work was kept under the direction of Swayne and the immediate supervision of Frank Trask, Chief Geologist of Andes.

The significant part of the El Salvador story is the continuity of effort on the part of Anaconda geologists, and the coordination of that effort with mine management which, extending over a long period of years, ended in the discovery of an ore body of the first magnitude. Results attained justify the expectation that unremitting efforts on the part of field geologists to record correctly and accurately the factual data of rock relationships, structure, mineralization and alteration, coupled with effective geological research, will produce other major mineral discoveries.

GEOLOGY OF EL SALVADOR

WILLIAM H. SWAYNE
Chief Geologist for
South American Operations

FRANK TRASK
Chief Geologist,
Andes Copper Mining Co.

El Salvador is a major porphyry copper deposit located along the trend of the Great Copper Belt of the Chilean Andes. The mine itself lies in Atacama Province about 75 miles from the coastal town of Chañaral and 20 miles from Potrerillos. The area is impressive because of widespread bleaching and alteration associated with acid porphyries intruded into predominantly dark-colored andesitic host rocks. The light-colored igneous intrusive rocks of Indio Muerto Mt., with which El Salvador orebody is associated, rise to 11,000 ft, approximately 3500 ft above a drab alluvial plain. Indio Muerto is a prominent peak on one of several north-trending foothill ranges of the main Andean volcanic chain, which lies approximately 65 miles to the east. During an early erosion cycle thick regional accumulations of poorly sized and poorly stratified cemented gravels were deposited on a surface of considerable relief. These gravels have been dissected by a number of deeply incised transverse canyons, which originate in the watershed areas and intermountain basins of the high Cordillera, continue with gradually decreasing gradient across the broad alluvial central valley west of El Salvador, and then cut through the Coastal Ranges to the Pacific Ocean. Indio Muerto Peak is a residual butte prominently sculptured by more recently formed, steep, and generally radiating gulches. A thin surface mantle of loose rock is now developing on its lower flanks, which are devoid of vegetation and soil cover.

The present climate is arid, with less than ¼ in. annual rainfall at lower elevations. Infrequent local flash floods result from occasional storms, usually centered in the higher mountains to the east.

GEOLOGICAL SETTING

The oldest rocks exposed in the district are predominantly andesitic bedded volcanics tentatively assigned to the middle and upper Cretaceous period. They include flows of various grain sizes and textures, agglomerates, and tuffs. Locally, rhyolites are interbedded. This thick volcanic series has been broadly arched, strongly folded, faulted, and overthrust within the framework of the main Andean uplift. Younger rhyolites and succeeding intrusives, believed to be Tertiary, have been localized by major regional structures. A broad band of intrusive rhyolite dikes and sheets with a barren monzonite porphyry extends for several miles to the southwest of Indio Muerto Peak, marking the major structural axis along which El Salvador center of intrusion and mineralization occurs. Mineralizing activity along the NE-SW trending structural axis is in a belt three miles long by one mile wide. Within the zone several centers of better-grade copper mineralization and more intense alteration are localized by intrusive rocks. El Salvador is the southernmost and largest of these centers. Occasional small, scattered argentiferous lead-zinc veinlets fringing the copper mineralization testify to a weak, widespread metal zoning.

Northwesterly and northeasterly conjugate fracture zones have influenced the location and shape of El Salvador intrusive complex. A pervasive system of repeated fracturing and shattering must have preceded, accompanied, and outlasted the emplacement of even the youngest intrusive rocks.

INTRUSIVE ROCK TYPES

The western and eastern flanking ridges of Indio Muerto Mt. are capped with an arched, broken, sericitized, and silicified rhyolite sheet. The rhyolite is light-colored, dense, flinty to felsitic, and locally banded. Fragmental and tuffaceous phases are present. Younger mineralized intrusives that occupy the central portion of the mountain-mass are exposed in the deep amphitheater-like canyons where

View of Indio Muerto Mt., looking northeast into Granite Gulch. Light-colored siliceous rhyolites capping dark underlying andesites. Quartz porphyry capping high central ridges in background.

erosion has cut through the hard rhyolitic cap rocks. The oldest of these, a fine-grained granodiorite, is present as dikes and a stock-like mass irregularly peripheral to a central plug of coarser-grained granodiorite porphyry. The granodiorite can be recognized by its fine-grained texture when fresh and by a characteristic granular aplitic appearance where the rock is altered. The adjacent granodiorite porphyry is characterized by plagioclase phenocrysts and prominent dark biotite books. Contacts of these intrusives with andesites are sharp in detail but generally irregular, with local zones of brecciation into which dikelets and masses of the intruding rocks have penetrated, engulfed, and partially replaced the older formation.

Quartz porphyry, having a fine-grained aplitic groundmass studded with prominent zoned plagioclases and rounded-to-hexagonal quartz phenocrysts of ⅛ to ¼-in. size, invades the earlier intrusives and volcanics as dikes and irregular lenticular sills. These form prominent, hard, siliceous outcrops which cap the central arcuate ridges of Indio Muerto Mt. rimming Turquoise Gulch. In the deeper mine exposures only narrow dikes of quartz porphyry have been found. These may be feeders for the larger outcropping masses which appear to have spread out under and over the rhyolite cap to occupy an intermediate, crudely layered position between the rhyolites and the softer, altered, mineralized andesites and the earlier intrusives.

Younger, unmineralized, and generally weakly altered latite dikes, inconsequential in number and size, occupy several of the more prominent, late northwest fractures.

Angular and rounded fragments of this latite and earlier rocks are found in several pebble* dikes which cut the mineralized zone and appear to represent a late effect of intrusive activity.

Infrequent tourmaline breccias, in the form of small, irregular, widely scattered pipes and dikes containing pyrite but devoid of copper, are associated with late phases of mineralization.

PRIMARY MINERALIZATION

Primary sulfide mineralization occurred after the intrusion of the quartz porphyry but prior to the formation of the latite dikes. This mineralization is genetically related to the porphyries, but it is neither evenly distributed within nor confined to any one intrusive rock.

A major influence in localizing the mineralization and alteration effects has been the repeated extensive fracturing of both intrusives and other host

* At El Salvador the term *pebble dike* describes relatively narrow post-mineral dikes filled with both rounded and angular fragments of varying size, usually occuring in a fine-grained, clastic matrix.

Early diamond drilling in Turquoise Gulch. Note barrels and tanks for re-circulating scarce drill water. Hard, silicified, limonite-stained quartz porphyry outcrops cap the arcuate ridges at head of Turquoise Gulch and overlie softer, bleached, argillized granodiorite porphyry.

rocks with timely shattering and brecciation, particularly well developed in areas marginal to the contacts. Individual fractures vary in size from tiny microscopic cracks to faults having several inches of well-developed clay gouge. They are unevenly distributed in varying degrees of parallelism to predominant criss-crossing orientation and represent all ages spanning the primary and secondary mineralization cycles.

Copper mineralization is more concentrated in the peripheral areas of El Salvador intrusive complex and in the andesites marginal to the contacts. The copper zone is fringed concentrically on its outer edges by a more pyritic halo located in the andesites and rhyolites. Seams of specularite are present in the rhyolite cap rocks fringing and above areas of sulfide mineralization. These mineralizing effects and their accompanying alteration are more widely distributed than the limits of commercial ore and cover a crudely circular area more than a mile in diameter. The zone of primary copper mineralization and the associated, more restricted chalcocite enrichment orebody show remarkably concordant relationships to the steep arcuate ridges surrounding the deeply eroded topographic basin of Turquoise Gulch.

Associations of better-grade primary mineralization with distinctive textural and mineralogic features have been observed. The most important primary ore mineral, chalcopyrite—normally confined to the granodiorite, granodiorite porphyry, and quartz porphyry—occurs as disseminations and in numerous interlacing veinlets with accompanying glassy granular quartz. Bornite is commonly observed but, in general, is sparsely distributed except in a few centers of better-grade primary ore. Molybdenite, as fine disseminations and tiny veinlets, is an important accessory mineral often associated with an increase in quartz veinlets. Pyrite is widely but unevenly distributed throughout the mineralized area in fine seams, well-formed veinlets, and disseminations. A mineral zoning is evident, with pyrite becoming appreciably more abundant toward the outer margins of the orebody and in the country rock. In terms of the orebody as a whole, pyrite is not relatively abundant, and the ratio of iron to copper appears abnormally low when compared to other porphyry copper deposits. Enargite and a mixture of enargite and famatinite have been observed in occasional cross-cutting veinlets, but they are mineralogical curiosities.

PRIMARY ALTERATION

Important mineral relationships and alteration effects associated with the primary mineralization may be observed in the deeper mining levels where they have not been obscured by supergene processes. Early quartz veins or dikelets have sharp contacts but no accompanying alteration envelopes. The earliest quartz is gray and glassy. Subsequent quartz veinlets, often with associated orthoclase and without alteration envelopes, have sucrose texture and may carry appreciable chalcopyrite and bornite.

Alteration of original mafic minerals to biotite is widespread. Evident in the andesites, such alteration is also noticeable in those parts of the intrusives in the vicinity of the orebody. It is most easily seen on the lower haulage levels. In the shallower zones of more intense oxidation, effects of any pre-existing biotization have been obscured by bleaching.

A deep central zone of early anhydrite-flooding and veining, exposed on the lower levels, is associated locally with molybdenite and bornite mineralization. The anhydrite toughens the rocks and reduces their permeability.

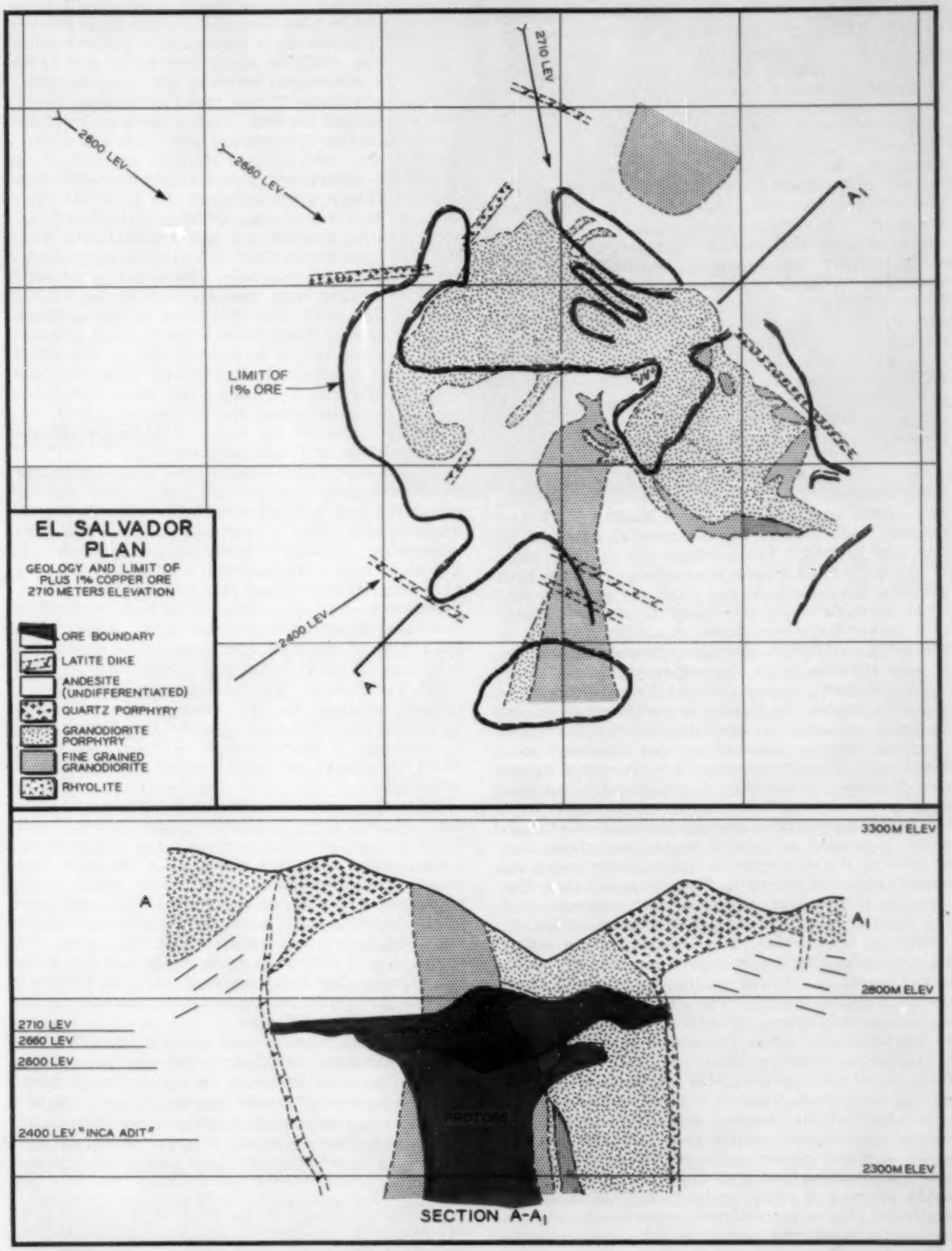
In central portions of the mineralized zone younger pyrite-quartz veinlets, with or without accompanying chalcopyrite, are bordered by normal hydrothermal alteration envelopes. These grade outward from narrow sericitic margins close to the vein boundaries, through relatively narrow bands of argillic alteration, into fresh rock. Tourmaline is a common associate of these veinlets. Late pyrite seams in the outer fringe zones of mineralization contain little or no quartz and are accompanied by low-intensity, dark greenish chloritic alteration envelopes.

SECONDARY ENRICHMENT

Oxidation with its consequent secondary enrichment has converted the primary copper sulfides almost entirely to chalcocite, forming an enriched blanket of extraordinary lateral extent and unusual thickness. While chalcocite is by far the most important sulfide mineral within the enrichment zone, small amounts of covellite and minor relics of chalcopyrite and bornite are observed. Chalcocite, both the sooty and gray, steely variety, is finely to coarsely disseminated and often intimately associated with dark, fine-grained biotite clusters. It is common as coatings on pyrite and also occupies solid veinlets ranging from several inches wide down to microscopic size. The irregular distribution of chalcocite within the enrichment blanket appears to reflect original inequalities of the primary copper sulfide distribution. Locally, minor amounts of cuprite and native copper are found in veinlets near the bottom of the enrichment zone.

THE OREBODY

Most of the ore reserve at El Salvador is in a secondary chalcocite blanket that exhibits marked local irregularities and extreme variations in eleva-


2710 LEV
2600 LEV
2660 LEV
LIMIT OF
1% ORE
2400 LEV
A
A1
EL SALVADOR
PLAN
GEOLOGY AND LIMIT OF
PLUS 1% COPPER ORE
2710 METERS ELEVATION
ORE BOUNDARY
LATITE DIKE
ANDESITE
(UNDIFFERENTIATED)
QUARTZ PORPHYRY
GRANODIORITE
PORPHYRY
FINE GRAINED
GRANODIORITE
RHYOLITE
3300M ELEV
2800M ELEV
2300M ELEV
2710 LEV
2660 LEV
2600 LEV
2400 LEV "INCA ADIT"
PROTORE
SECTION A-A1

tion of both its top and bottom. It is generally discordant with the present erosional surface. The orebody varies in thickness from a few feet at the edges to more than 950 ft in its central portion and covers an area 1700 x 4000 ft. It is crudely crescent in plan, having it major lateral axis oriented in a northwest-southeast direction with curved horns wrapping northward around a mass of poorly mineralized to barren granodiorite porphyry. The strongest chalcocite mineralization and its deepest extensions are localized in zones of intense fracturing and brecciation, within and marginal to the intrusive complex. The bottom of the ore zone is usually quite sharp near its thinner edges, particularly where protore grades are low. The lower limits beneath better-grade, thicker ore columns are often less distinct, with gradual transition to clean primary mineralization. Evidence of a deep central core area of brecciation and associated better-grade primary sulfides probably has important significance with relation to the overlying chalcocite blanket. Occasionally the bottom of the chalcocite enrichment reaches a depth of 2000 ft below the surface. The upper limits of the ore blanket are usually quite sharp, accompanied by an abrupt increase in grade between the highly leached capping and the top of the enrichment.

LEACHED CAPPING

An impressive halo of intense surface bleaching and alteration surrounds Indio Muerto Peak and extends well beyond the commercial limits of El Salvador orebody. These effects are crudely zonal to centers of more intense mineralizing activity, both primary and secondary, and gradually diminish outward through concentric zones of lower intensity into darker fresh host rocks. A similar decrease in bleaching and softer alteration mineral assemblages is most striking below the sulfide enrichment zone.

The leached capping over El Salvador ore zone is deeply exposed by Turquoise Gulch and is similar in many respects to those found over the other porphyry coppers. Successive cycles of erosion combined with climatic variations have promoted oxidation processes, producing a thoroughly leached capping zone varying between 180 ft to 1500 ft in thickness. Pulverulent maroon limonite after chalcocite is present in isolated specks and cracks but, in general, the characteristic red limonite colors are greatly subdued except in freshly opened cuts. The limonite distribution reflects only in a general way the location of the better chalcocite zones below. Yellow to brown iron oxides, usually accompanied by abundant interlacing quartz veinlets and occasional traces of thin red coatings confined to small empty cavities, prevail over considerable areas of chalcocite enrichment but are commonly marginal to the better ore zones. The coated cavities are interpreted as resulting from early thin chalcocite films on primary pyrite grains which were removed during continuous, relatively rapid downward encroachment of the leaching process. Related to the poorly mineralized central core area are several zones of weak copper-oxide staining and areas of less intense bleaching and alteration. The copper-oxide staining is often preferentially absorbed by argillized plagioclase feldspar residuals. Anomalous chalcocite bands and barren bright pyrite horizons perched locally within the leached capping above the chalcocite ore blanket indicate irregularities in permeability of the cap rocks during the processes of supergene enrichment.

APPLIED GEOLOGY

Concentrated geological effort resulted in development of El Salvador orebody. The detailed field work included surface mapping of an area 2 miles wide by 4 miles long. Transit and plane table surveys provided a preliminary triangulation control which was used to establish claim boundaries and check points for subsequent brunton and tape traverses. Field observations of rock types, structures, alteration facies, and leached capping features were recorded in detail. The original field work was supplemented by microscopic studies at the Butte geological laboratory. Coordination between field and laboratory work provided the basis for more detailed field studies upon which a preliminary diamond drilling program was based. Initial holes were inclined from the surface to take maximum advantage of the steep topography. Continued exploration included drilling from tunnels driven in the leached capping and later into the heart of the orebody. Where possible, these holes were directed to penetrate the blanket of secondary ore on 100-meter centers at predetermined horizons. This provided a systematic grid of geologic and assay data upon which the broad plans for mining were laid out, including locations of main entries, ore passes, haulage levels, and ventilation openings.

In conformity with conventional practice all drill cores were split. Half was sent for analysis and the remaining half was subjected to detailed geological mapping and study, in most cases under a binocular microscope. One-half of every piece of core taken at El Salvador is catalogued and filed at the property as a complete record and valuable reference source. Frequent re-studies of these cores have resulted in new ideas beneficial to ore-finding. As of July 1959, 245,113 ft of diamond drill holes were completed with approximately 80 pct core recovery.

All exploration and development headings are mapped geologically and sampled in continuous horizontal cuts. The normal assay inclusion is 5 ft. Car samples of tunnel drives in the ore zone are taken for checks and confirmation of the channel sampling.

All geological information and pertinent sample data obtained from the surface, mine openings, and drillholes, are recorded on both plans and sections. Underground notes are taken on 1:500 scale and recorded on level plans of the same scale. Assay plans are prepared as overlays for the geologic plans. Diamond drill holes are mapped on 1:100 scale and these notes, together with assay data, are recorded on 1:1000 scale cross sections of the individual holes. The sections also show all other penetrations in the area and any significant data pertinent to the layout of ore blocks.

Geological projections and predictions within the mineralized zone, including ore reserve calculations and all ore block planning, are accomplished from 1:2000 scale level plans and coordinated north-south and east-west cross sections of the same scale. These are posted currently with all geological and assay data and serve as basic guides for mining operations.

Geology at El Salvador has been primarily instrumental in the discovery and development of this important porphyry copper orebody. Persistent application of geology will continue to have a fundamentally important part in the problems of efficient ore extraction and in the search for new ore.

ENGINEERING CONTROL

by R. W. PULLEN
Chief Engineer,
Andes Copper Mining Co.

When the existence of a large orebody under Indio Muerto Mountain was indicated by preliminary drilling, an aerial survey company was engaged to photograph the area for the purpose of making topographic maps. The map coverage was composed of two sets, one on a scale of 1 to 20,000, with a contour interval of 20 meters, and the other on a scale of 1 to 5000, with a contour interval of 5 meters. Conducted jointly by engineers of the Andes Copper Mining Co. and the aerial survey company, the ground control resulted in a triangulation system which provided the basic surveys at El Salvador mine.

The plan of mining development required an initial underground connection between two levels that are 656 ft apart vertically. The closed survey for this connection was about 32,800 ft long. The original connection was the pilot raise for one of the inclined ore passes, which was about 700 ft long. Because of the excessive length of this initial opening it was necessary to drill inclined diamond drill holes more than 330 ft long to connect with the pilot raise at as low an elevation as possible. This was done for the benefit of ventilation in driving the top one third of the pilot opening and required a degree of accuracy in surveying that warranted unusual care in making horizontal angular measurements as well as all linear measurements.

The steep topography of the region made location of base lines difficult. A final selection of sites resulted in the establishment of two main base lines, 1640 and 1968 ft long respectively, which are 3.596 miles apart horizontally and 1388 ft apart vertically.

Careful attention was given to strength-of-figure quadrilateral shapes in locating triangulation points. The base lines were marked by steel stanchions set in concrete which had steel top plates inclined to grade. A 50-meter nickel-steel special baseline tape was used for measuring the base lines with the usual procedures for tension and temperature readings. The angles were turned with an instrument reading directly to single seconds and having a micrometer vernier reading to 1/10 of 1″.

These precise measurements resulted in a difference between calculated and measured length of the lower base line of 2 ml in 600 meters, indicating an error of 1 in 300,000.

Angular point closure of 3″ was obtained and similar precision was used on quadrilateral closure. All angles were adjusted to figure closure using the law of sines method.

The balance of the closed survey was composed of underground traverses, which were run with angular measurements of similar accuracy, using a 100-meter steel tape with standard procedures for tension and temperature readings. Periodic linear comparisons were made between the traverse tapes and the baseline tape.

The leveling was carried out with a late-model self-leveling instrument. The standard formula was used to obtain a value between first and second order precision. All elevations were checked trigonometrically by vertical angle measuremets to the nearest second, resulting in very close checks with direct leveling.

The end result of all these refinements in survey measurements was the eminently satisfactory holing-through of the diamond drill hole and the ore pass pilot raise in near-record time for that class of work.

DEVELOPMENT OF EL SALVADOR MINE

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General Superintendent,
Andes Copper Mining Co.

W. H. DUNSTAN
Mine Superintendent,
Andes Copper Mining Co.

T. H. DUDLEY
Assistant Mine
Superintendent,
Andes Copper Mining Co.

LLOYD POLLISH
Mine Foreman,
Andes Copper Mining Co.

El Salvador's rock outcrops are the result of differential erosion which, in general, has left a hard capping of rhyolite. It is expected that this hard capping will inhibit the dilution of ore grade in a caving operation.

Although the enrichment blanket, which constitutes the mineable orebody, is of extraordinary lateral extent and unusual thickness, it is also characterized by local irregularities and by variations in the elevation of the bottom of good ore that are, in places, quite abrupt. Mineable values are overlain by barren material that varies widely in thickness and averages three times the ore thickness.

The following factors influenced the selection of a mining method:

1) An average ore grade of 1.5 pct total copper, with reserves of 375 million tons.

2) Initial production of 12,000 tpd, to be expanded to 24,000 tpd.

3) Ore zones ranging from 80 ft to more than 1600 ft in horizontal dimensions and varying to 740 ft in thickness, with an average thickness of about 425 ft.

4) An irregular ore zone bottom.

5) A column of waste averaging 1300 ft in thickness overlying the ore zones.

6) High degree of fracturing in the mineralized mass.

7) Certain underground mining methods estimated to be cheaper and quicker than open pit mining.

After consideration of these factors, it was decided that block caving with gravity ore disposal was the method best suited to existing conditions. Accordingly, a plan of mining was devised which provided two haulage levels, referred to by their elevations in meters above sea level as the 2600 and 2660 levels. Development was started by driving from surface at both horizons. Each of the two levels, which are operated simultaneously, has two sections separated by an unmineable interval. Each section will eventually have two blocks in full production with other blocks in various stages of development. Under these conditions the mine will have capacity to produce 24,000 tpd on three shifts.

The ore is hauled to either of two ore pass locations for gravity disposal to ore bins feeding a main adit haulage system that leads directly to the coarse crushers at the concentrator.

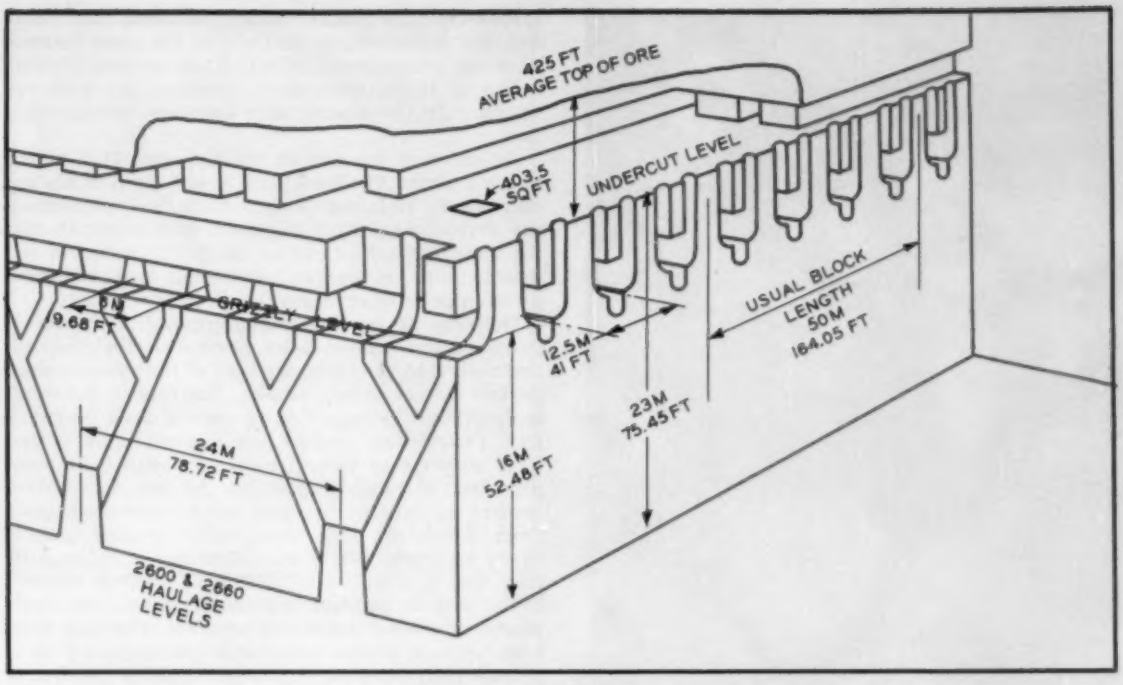
Level Development: The decision to have two mining levels was influenced by the average elevation of the bottom of the major part of the orebody and the adverse diluting effect an attempt to reach all the developed ore from one level would have. The 2600 and 2660 haulage levels were selected at such elevations that each of the two mining levels, 75.4 ft above the haulage level, coincides with the bottom of most of the developed ore with a minimum inclusion of low-grade material.

A loop traffic pattern on the haulage levels provides one-way movement of ore trains to and from the dumping stations and in the crosscuts under the blocks.

Within the mining areas the haulage crosscuts are driven on 78.7-ft centers in order to provide for a four-grizzly main-raised system. From previous experience, this pattern of gravity disposal was considered to be the most efficient and, at the same time, it placed the mining horizons at the desired elevation. All drifts and crosscuts on the haulage level have 10x12-ft rock dimensions. The ground is extremely variable in hardness and competence and calls for a corresponding variation in drilling, blasting, and ground support methods. Jackleg drills are used with ⅞-in. hexagon carbon drill steel having 1⅜-in. tungsten carbide insert bits in hard ground and throwaway bits in soft ground. Rounds have 25 to 50 holes, depending on the ground, with holes 6 to 8 ft long. Blasting is done with 1x8-in. dynamite, detonated with fire fuse fitted with connectors and wired for proper timing with ignitor cord. Broken rock is shoveled up with air-operated loaders into 5-ton Granby-type cars hauled by 10-ton battery or trolley locomotives.

Much of the ground requires some kind of support. In areas where rock bolting is sufficient, ¾-in. x 7-ft rock bolts with expansion shells, holding 8x8x½-in. plates, are located on 5-ft intervals or wherever the pattern of the ground structure dictates. More often timber sets are used, placed on 6-ft centers. The 8x8-in. or 10x10-in. posts are 9 ft 1 in. long, with matching caps 10 ft 10 in. long. Occasionally, 8x10-in. or 10x10-in. wide flange steel caps are used instead of timber. Turnouts on the haulage levels are usually supported by a series of graduated 10x10-in wide flange steel caps on wood posts.

A part of the 2660 level adit encountered heavy ground where it was necessary to use arched steel sets with reinforced concrete. No. 8 reinforcing rod was spot-welded to the sets in a box work mesh,



Isometric diagram of block section at El Salvador.

and concrete was blown into the wood forms with a pneumatic placer.

Block Development: Most blocks are 157.4 ft wide by 164 ft long. Width is determined by haulage drift spacing and length by multiples of the grizzly drift spacing. From the two haulage crosscuts under each block a branched raise system, lying all in one plane, connects to the grizzly level 52.5 ft above. From the main raises, which intersect the floor of the grizzly drifts on 19.7-ft intervals, branch raises on both sides of the grizzly drift lead to the undercut level 23 ft above to give a drawpoint pattern having a unit dimension of 19.7 x 20.5 ft.

Main Raises: These openings, 5x5-ft inside, are inclined at 50° from the horizontal. They originate in pony sets that have previously been installed above the haulage crosscuts on 41-ft intervals that correspond to the grizzly drift intervals. Since each main raise has a backover branch, four grizzlies feed each pony set. This system of main raises is duplicated in the companion haulage crosscut so that there is a line of eight raises connecting with each grizzly drift. The raises are driven untimbered if ground conditions permit; otherwise they are cribbed with 5x10-in. framed timber.

Grizzly Drifts: The 5x7-ft grizzly drifts are on 41-ft centers. Originally, to facilitate mucking, the practice was to drive these openings after the main raise driving. Wherever timber can be used the drifts are supported by 10x10-in. framed sets with girts at top and bottom. Grizzlies are on 19.7-ft centers and have 16-in. clear openings between grizzly rails.

Since the inception of mining, because of heavy ground, timber in grizzly drifts is being largely supplemented or supplanted by monolithic concrete lining, usually poured in an arched cross section. No re-inforcing is used except for a beam or rail that is placed across the top of the branch raise opening to resist abrasion. To date the concreted sections, and the drawpoints in them, have stayed open and in workable condition with little or no repair. Steel forms, which bolt together and are easily recoverable, make up the four-piece section, and the concrete is placed pneumatically. More recently the grizzly drift has been driven successfully as a small pilot opening without timber and prior to holding main raises from below. Mucking is done by a scraper. Enlargement in short sections, followed immediately by concreting, has made it unnecessary to provide temporary timber support.

Branch Raises: At each grizzly position, on both sides of the grizzly drift and at right angles to it, a branch raise is collared with a short drift round to establish a brow. The branch raise is then driven up at 50° from the horizontal to a point about 13 ft from the side of the grizzly drift. From this point the raise is branched in four directions, fanning upward and outward to the undercut level, a distance of 23 ft vertically above the grizzly drift floor.

Undercut Drifts: Undercut drifts, 5x7 ft in cross section, are driven on 19.7-ft centers at right angles to the grizzly drifts and parallel to the haulage crosscuts. As these drifts are driven, rock is disposed of through the previously driven branch raises. The undercut drifts are connected by crosscuts, located either at each end of the block or wherever ground conditions may permit.

Undercutting: Undercutting is performed by drilling and blasting out the pillars remaining between branch raises and between undercut drifts. Drilling is generally accomplished from the tops of the branch raises. The sequence of undercutting is determined by ground conditions, with the object of taking the weaker ground first and retreating back toward the more stable sections of the block. On the undercut level, ground is supported with timber stulls only when necessary to maintain access until the block is undercut.

Source of production after caving action has been induced is on grizzly level where rock is kept flowing from branch raises through grizzly to trains below.

Man and material access raises are put up to connect the haulage drift to a stub of a grizzly level crosscut to service a group of blocks. Emergency manways connect the grizzly level with the undercut level when safe and adequate communications are not afforded by the regular branch raises.

Main and branch raise rounds are drilled with stopers using ⅞-in. hexagon carbon steel and throw-away bits. Grizzly and undercut drifts are drilled with jacklegs. Dynamite of 35 pct strength and fuse and caps are used in blasting.

The following table summarizes development footages for a standard block 157.4 ft wide by 164 ft long:

Haulage Crosscuts	410 ft
Main Raises	1260 ft
Grizzly Drifts	840 ft
Branch Raises	4408 ft
Undercut Drifts	1548 ft
Manways	50 ft
Undercutting	25,814 sq ft

Slusher Block Development: In an important area of the mine, on the 2600 level, recent development has shown that the ore bottoms at the haulage level, or close to it. The conventional gravity block layout, therefore, would sacrifice considerable mineable ore. To recover this ore a system of slusher mining was decided on that would permit lowering the mining level to the minimum elevation above the haulage level, already partly opened up in the area.

The slusher blocks generally will be 118x164 ft, with haulage crosscuts on 236-ft centers. Slusher lanes are at right angles to, and 10 ft above, the floor of the haulage crosscut. These 7.5x7.5-ft slusher lanes, on 41-ft centers, are driven raw as pilot drifts, then enlarged and concreted to full dimensions. No re-inforcing is used other than a steel beam placed at the brow of the branch raise opening.

Branch raises are driven at right angles to the slusher drift on 10-ft centers and staggered on each side of the drift. Branch raising, undercut drift driving, and undercutting are done in the same manner as in the conventional gravity block system. Slusher hoists of 75 hp with 60-in. scrapers are used for slushing the ore directly into the 5-ton Granby-type cars.

Adoption of the slusher method adds 43 ft of ore to the column. The grizzly level and main raises are eliminated, reducing considerably the amount of the development work required. It is expected that the increased cost of extraction due to provision and maintenance of slusher equipment will be offset by savings in labor cost.

Delivery of Concrete Underground: Concrete is prepared at a surface batch plant near the plantsite and delivered to one or another of the mine surface portals in transit-mix trucks. The mix is delivered underground in rocker dump cars of 3-cu yd capacity. Distribution centers are located so as to deliver concrete to mining blocks through 6-in. steel pipelines of minimum length. At the distribution centers the cars are dumped into a receiving hopper from which the mix flows, or is scraped, into a ½-cu yd pneumatic placer. Recently a churn drill hole, which is centrally located as regards accessibility both on surface and underground, has been placed in use for delivering concrete. The long haul from surface is thus eliminated and replaced by a shorter haul from the churn drill hole to the distribution centers.

UNDERGROUND EXTRACTION AND HAULAGE

Ore drawing follows schedules which are issued daily to the shift bosses to insure uniform draw and maximum tonnage recovery with minimum waste dilution. Plans and bar diagrams, showing cumulative tonnage drawn through each grizzly, are kept up to date as a guide to the extraction foreman.

Grizzlymen, working two to a shift, pass the ore from the branch raises and through the grizzlies into the main raises below. Secondary breaking is done as necessary, the grizzlymen using sledges and also blasting with dynamite, instantaneous electric caps, and single-shot magneto.

Ore Haulage: At the pony set, car loading is controlled by manually operated arc-type gates. Each ore train is composed of 12 5-ton cars drawn by a 10-ton trolley locomotive. Multiples of car lengths

Ten-ton locomotives with trains of 5-ton cars load the ore from the chutes at the bottom of the main raises and haul it to the dumping points at the top of the ore pass system.

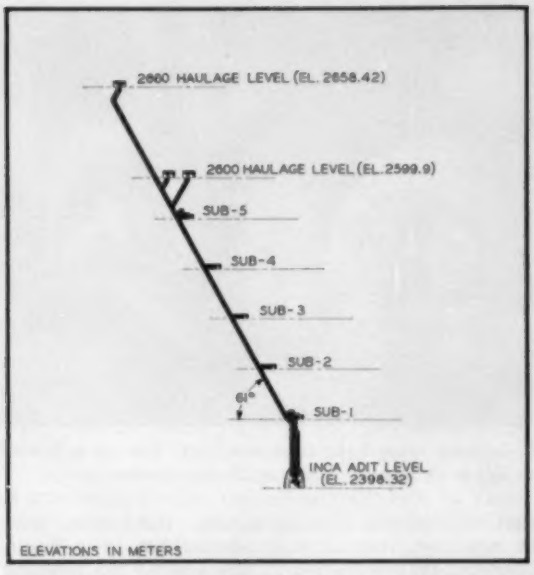


Diagram of ore pass and ore bin showing 2600 and 2660 levels in relation to Inca adit. There will be four such ore passes to serve El Salvador.

match the chute interval so that cars under adjacent chutes are loaded simultaneously.

The trains operate on meter-gage (3-ft, 3⅜-in.) track composed of 70-lb rail. Ore is dumped into any one of four ore passes leading to bins directly above the Inca adit level.

An average cycle for an 1800-meter round trip totals 27½ min: loading, 15 min; tramming, 10½ min; and dumping, 2 min.

A two-way radio dispatching system with a microphone and speaker on each locomotive is used to control all train movements from a central dispatching point on each haulage level. This system is supplemented by a conventional hand-operated signal light system. Separate radio frequencies are used on each of the two gathering haulage levels and on the Inca adit level below.

Ore Pass System: The ore pass sites were chosen first so as not to be in mineable areas and, second, to be in as firm ground as could be found outside mineable areas and still within reasonable hauling distances.

The four ore passes are grouped in pairs, with a supply and access manway serving each pair. Each ore pass is 6 ft wide by 8 ft high and 707 ft long at an inclination of 61° from the horizontal, from the top of the ore bin to the 2660 level. A 72-ft pillar separates the two ore passes in each group and a 49-ft pillar separates the nearest ore pass from the parallel manway.

Below the 2600 level a branch ore pass was driven to intersect the dumping station on that level; on the 2660 level, branch ore passes intersect two parallel dumping drifts. The ore passes are unsupported except between the 2600 and 2660 levels, where they are concreted owing to weak ground conditions.

Sublevel drifts at 107-ft intervals connect by short crosscuts to each ore pass and to the manway providing access. At sublevels 1, 5, and 7, air-operated gates are installed for control of ore flow.

Ore Bins: The ore passes discharge through air-operated control gates into cylindrical vertical ore bins of 1500-ton capacity, each 125 ft high and 18 ft in diam. Ore bin walls are unsupported and were excavated to their working dimension by enlarging a previously driven two-compartment pilot raise by shrinking upward from the bottom. The 50-ton cars on the Inca adit level are loaded from the ore bins through air-operated drop lip gates, which discharge into the continuously moving train.

Manways: Each of the two service manways provides access to its respective ore pass system for personnel operating the control gates and for maintenance and repair. Each manway is 8x14 ft in cross section, with cage and ladder compartments, and is timbered with six-post sets except for certain sections which are concreted. The manways are inclined at 61° from the horizontal so that they lie in the plane of the ore passes and the slope length of each is 964 ft from the Inca adit level to the 2660 level.

Manway cages are raised and lowered by single-drum hoists. Each hoist drum is 45 in. long by 60 in. diam and is driven by a 100-hp, 720-rpm, 440-v, 3-phase, 60-cycle motor designed to develop a rope pull of 8000 lb at 368 fpm.

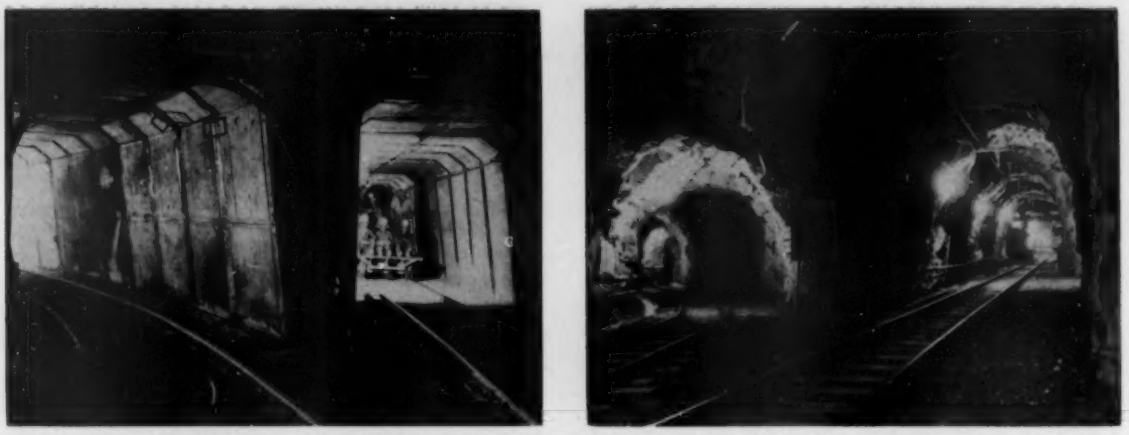
Construction: Both the ore passes and the manway were raised from the Inca adit level. Average rate of advance was 8.2 ft per day on a three-shift basis. Both the ore passes and the manway pilot raise were driven without timber. Drill stagings were supported by lengths of 2-in. pipe with clamps on drill steel driven into the foot and hanging wall. A second safety staging was carried about 3 ft below the drill staging. Two stopers were used to drill out a 25-hole, 6-ft round using a V cut. Blasting was done with Tronex No. 2, detonated by standard caps and fire fuse wired with ignitor cord. Air and water lines were carried up by the mining crew, which consisted of four men: two miners, one helper, and one tugger hoist operator. The ventilation of the last third of the driving of initial openings was greatly helped by connecting with several diamond drill holes from above through which the vitiated air was exhausted.

Inca Adit: The Inca adit takes its name from the Inca Trail, dating from pre-Spanish days, which is clearly visible within a short distance from the portal. The Inca adit was driven as a main haulage level to receive all ore by gravity from the two levels presently working and from subsequent levels which may be developed at a future date. Its elevation, about 8000 ft above sea level, is 730 ft below the lowest present undercutting horizon and is expected to be below all anticipated downward extensions of the orebody. The work done to date on this level amounts to 16,400 ft of tunnel, including a spur 1640 ft long to the north side ore pass system. In cross section it is a 14x17-ft horseshoe inside rock or timber measurements.

The ore is hauled on this level in 40-ton drop-bottom cars that are loaded, without stopping train movement, from two chutes under each ore bin which are 16 ft apart. The motive power is a 45-ton trolley locomotive which operates on 550 v dc and hauls 14 cars per trip.

The Inca adit* was completed in just over two years, with an average advance of 22 ft per day for the entire job. During one month the advance was 35 ft per day, and the greatest daily advance was 62.7 ft. A collapsible jumbo was used with jackleg drills, and the so-called *cuchufleta* was used

* See March 1958 issue of MINING ENGINEERING.



LEFT: Concreted turnout on the 2600 haulage level. RIGHT: Looking toward the Inca adit level. The ore is hauled in 40-ton cars on this level a distance of about three miles to the coarse crusher at the concentrator.

in the mucking-out operation. This latter device was a train of bottom-dump cars adapted to hold a full round of 130 tons. A scraper operating on a trestle built into the tops of the cars took the broken rock from the hopper at the front end and filled progressively toward the rear. A crawler-type diesel shovel kept the hopper full from the muck pile at the face. Average mucking time was 1.39 hr. During driving, air was exhausted through a 38-in. diam rigid pipe at about 20,000 cfm, so that the fresh air base was never more than 200 to 300 ft from the working face.

After driving was completed and a connection made to the 2600 level, the 38-in. ventilation tube was removed. At the same time the temporary track, installed while the tunnel was being driven, was replaced by new 90-lb rail and new ties, with washed and sized rock ballast. Also at the time the ventilation tube was removed, the trolley wire, with accompanying feeder line, was suspended from the roof with rock bolts and cross arms especially provided for that purpose.

Electrical Distribution: Power from the company-owned Barquito plant at the seacoast about 70 miles away is delivered at 88 kv to the main substation at El Salvador, where it is stepped down to 13.8 kv. Two lines from the substation connect to a 5000-kva transformer bank at the mine, where the voltage is further reduced to 2400 for mine use. The electrical distribution systems on both the 2600 and 2660 levels are similar. Power to the underground rectifier stations for 250-v d-c trolley haulage is conducted by twin 250-MCM cables on each of the two levels. The feeder lines are connected to metal-clad switchgear at the rectifier stations, where separate take-offs feed each of two 300-kw mercury arc rectifiers operating in parallel. Two other breakers on the switchgear provide a-c power to feeder cables leading to ventilation fans, slushers, and other auxiliaries. Individual transformers close to the point of consumption step this power down to 440, 220, and 110 v.

The trolley network employs a bare 500-MCM feeder cable suspended just above the 4/0 trolley wire and connected to it at 10-ft intervals. A bare ground cable located on the side of the drift and connected to the track at regular intervals insures a good circuit.

Mining sections are protected by automatic circuit breakers on the entry and exit lateral to each section. Within the mining section, the trolley wire in any one crosscut may be isolated by a hand-operated trolley switch at one end of the crosscut and a dead-end at the other. The respective positions of the hand switches and dead-ends are reversed in adjoining crosscuts so that an overload in one of the laterals will trip only one of the two section breakers, leaving half the mining section energized.

Ventilation: Early in the development of El Salvador it was decided to use the exploration tunnels and inclined shaft as principal ventilation openings, supplemented by additional openings as needed. The primary ventilation system was established on the principle that means of ingress should also be sources of fresh air. The main fans at the collar of the exploration shaft exhaust 300,000 cfm at a pressure loss of about 6 in. water gage and the three tunnels presently serve as the source of most of the fresh air.

Each of two 150,000-cfm axial vane fans is driven by a 250-hp motor, and the installation is so designed that the two fans can be separated and used individually on replacement exhausts whenever the exploration shaft must be abandoned because of subsidence. These main fans are at the collar of the inclined ventilation shaft. To keep friction losses to a minimum, a portion of this shaft was concreted and the remaining timbered section was lined with corrugated steel sheets.

The fresh air intake of about 300,000 cfm comes from three sources: tunnel No. 3 and the 2600 and 2660 mining levels. In anticipation of the time when tunnel No. 3 would become the largest source of fresh air, the first 1300 ft was lined with galvanized sheet and the remainder with gunite.

In general, air flow is such that each operating block has a source of uncontaminated air and separate circuits are needed for the blocks in each of the four mining sections. Ventilation for the grizzly levels is drawn from the main levels through ventilation raises outside the caving zone and is exhausted from the blocks by a series of ventliation raises and drifts connected to the main ventilation shaft. The only section not drawing air from the haulage level is the east, or interior portion, of the 2660 level which receives air coming down from tunnel No. 3 and exhausts through ventilation crosscuts to the main ventilation shaft. Development headings are exhausted from the face with 18 or 24-in. diam rigid ventilation tube.

Compressed Air: The 12,500-cfm compressor plant is located on surface between the 2600 and 2660 level portals. Each of three new two-stage machines, driven by a 400-hp synchronous motor, delivers 2500 cfm at 90 psi. In addition, a 5000-cfm machine from the old Potrerillos mine has been installed at the same plant.

Surface Installations: Largely because of surface topography, but also because the greater part of the ore reserve is tributary to the 2600 level, nearly all mine surface facilities have been located at or near that portal. The principal structure is the change house, built to accommodate 1024 men and divided in the middle by showers with mine clothes in one end and street clothes in the other end of the building. The time office, lamphouse, and safety department offices are in close proximity to the change house and to the track where the men board and alight from the main train. Shops are located away from the portal and are connected both by roads and by mine trackage. These include the drill shop, electric shop, timber framer and sawmill. A small mine warehouse is also in the shop area. Dynamite, fuse, and cap magazines are built underground and located at convenient distances from the 2600 portal. A hill separates them from that portal and from the surface installations. A general mine office, still to be constructed, for mine administration and geological and engineering personnel, will be located apart from the rest of the surface plant but conveniently close to the 2600 portal.

Since the townsite is some distance from the 2600 level surface area, all mine personnel are transported to and from work in company buses.

Main ventilation fans at top of inclined exploration shaft. These fans exhaust 300,000 cfm and use 500 hp.

SAFETY AND INDUSTRIAL HYGIENE

Andes Copper Mining Co. has always taken pride in its safety record. The company has won the Inter-American Award for Mines (Class B) for the last two years and The Anaconda Co. Kelley Safety Award for three of the last five years.

The safety and ventilation department at El Salvador occupies a spacious building at the 2600 level mine yard which provides offices, laboratories, and a lecture hall for training classes. The department is organized as follows: 1) mine safety and fire prevention, 2) mine ventilation and industrial hygiene, 3) plant and surface installation safety, 4) fire control and prevention, and 5) traffic control.

Mine Safety and Fire Prevention: All working places are inspected daily by the safety department inspectors, who work on all shifts when the mine is operating. These men supplement on-the-spot instructions with reports directed to mine supervision. For safety control, explosives orders are placed through the safety department, which also supervises delivery. Permissible practices in blasting are maintained by inspection.

All persons employed in underground haulage, such as motormen, switchmen, dispatchers, and their substitutes, are carefully selected for intelligence and reliability and trained by the department.

Training for supervision and mine rescue teams in first aid and oxygen-breathing apparatus is continuous. Further education is supplied by circulars and posters on various safety themes and special problems. An effort is made to vary the presentation to keep interest in old but necessary advice.

The fire prevention system for the mine consists of an independent fireline with hose connections in timbered areas, steel fire doors for isolating the various sections of the mine, and dry chemical fire extinguishers at all electrical installations. The main exhaust fans are equipped with reversing switches should this procedure be necessary in connection with fire control.

Industrial Hygiene: There is a dust collection and air-cleaning system at the ore passes. At the loading chutes in the Inca adit, dust is collected by hoods and ductwork and the air is passed through a wet impact dust collector from which cleaned air is discharged up the mechanized manway. A similar system is used at the 2600 level dump station with hoods above the grizzlies and a duplicate wet impact machine for dust separation. The 2660 dump station is ventilated adequately by an exhaust ventilation drift at the dump station connected directly to the main ventilation shaft.

The ventilation air flow is measured each month, when changes are made (such as holings-through), and when auxiliary fans are added or removed. Air samples for dust counting are taken periodically in all working places. Air analyses are made in suspect areas.

Plant and Surface Installation Safety: The beneficiation plant and all shops are periodically inspected to observe and correct working hazards. Statistics are kept on accident frequency and department heads receive a copy of the reports.

Fire Control and Prevention: All permanent buildings on El Salvador property are either fully or semi-fireproof, as well as earthquake-proof. In the mine yard, plant, and shop areas there are fire hydrants covered by houses containing hoses and other fire-fighting equipment. The plant area has a separate 100,000-gal water tank for the fire main and an additional 330,000 gal for fire protection reserve in each of the two feed water tanks. Throughout the townsite, there are fire hydrants connected to the 500,000-gal sanitary water reservoir.

The fire department, under direction of the safety department, consists of three groups of volunteer firemen, 10 men in each group, at the city, plant, and mine, respectively.

Fire-fighting equipment consists of a fire truck of the dry chemical type (1000 lb of chemical activated by compressed nitrogen) and a water-tank truck of 2000-gal capacity equipped with a pump. In addition to this there are 450 hand fire extinguishers in service.

Traffic Control: Road signs, guard rails, and center stripe are maintained on the company roads by the safety department. Safety officers patrol roads with the local police. Vehicles are inspected periodically and vehicle operators are licensed.

INTRODUCTION

by WILBUR JURDEN

President,
Anaconda-Jurden Associates Inc.

The vast Atacama Desert of northern Chile presents a strange picture to the newcomer. It is difficult for someone who has not been there to visualize its stern reality or comprehend the starkness of the region. Unlike the deserts of North America which support plant life such as sagebrush, greasewood, and innumerable varieties of cactus, the great Atacama Desert, stretching hundreds of miles along the coast and back a hundred miles or more into the Andes, is nearly devoid of vegetation. This is a bleak terrain—with little sign of human habitation, few roads, and scant water—swept clean by daily winds that often attain great velocity. There is practically no rainfall, but earthquakes are frequent and at times severe. Add to this picture the rarefied atmosphere of the high altitudes where the copper mines are located, and the eternal glare of sun in a cloudless sky, and it is possible to gain some comprehension of the difficulties encountered in constructing a large metallurgical plant in an adverse environment.

The first such venture of any magnitude was the gigantic plant of Chile Exploration Co. at Chuquicamata, which was started about 1912. The Chuquicamata project had the benefit of a railroad from the port of Antofagasta, Chile, to La Paz, Bolivia which passed about 20 miles from the plantsite. Except for this transportation facility, the engineers had to pioneer in solving the many problems inherent in this environment, such as distance from source of supply, development of water resources, and housing of construction personnel. At that time there was no air travel, no telephone to Chile, and practically no cable service. Reply to a letter from New York could be anticipated in about two months.

The ore at Chuquicamata was found to be extremely hard and dusty. Prior to that time no excavating, crushing, and conveying machinery had been devised to handle this class of material. Aggravating this situation, the start of World War I virtually isolated the project before it was fully completed. Despite these obstacles, the engineers and operators achieved partial production, which gradually increased, over a period of nearly seven years, to the intended capacity.

The next large project was the Andes Copper Mining Co. operation at Potrerillos, started in 1925. Acquisition of Chile Exploration Co. in 1923 gave Anaconda engineers the benefit of the pioneering experience of the Chilex staff, since the problems in both places were similar. The designers of the Andes plant had at their disposal more rugged and efficient crushing, conveying, and grinding equipment, both mechanical and electrical, developed after World War I and before the start of the Andes project. They derived further benefits by making improvements in mechanical design based on experience at Chuquicamata. The Andes plant was completed in less than two years after the start of construction and the first copper was poured late in 1926, a record made possible largely by the example of Chuquicamata.

El Salvador plant, 12.5 miles from Potrerillos as the crow flies, was started in 1957. Ordinarily it is no problem to transport ore from mine to concentrator for this short distance, but in this particular case a canyon more than a third of a mile deep and more than a mile wide presented a formidable geographic barrier. Even so, the transportation of ore from El Salvador to the existing Andes plant was at first assumed to be economically possible. After a number of schemes had been considered, one was evolved which appeared feasible. The plan was to haul by rail to the canyon's edge and construct a new crushing plant on the side of the canyon. The ore would then have been dropped into bins at the floor of the canyon and carried from there by belt conveyor up the opposite side to the Potrerillos plant.

At this point, the established practice of preparing careful estimates proved of great value. Calculations plainly showed that the scheme was not economically feasible either from the standpoint of construction or operation. The decision was made, therefore, to build a new crushing and concentrating plant adjacent to the principal mine portal at El Salvador and to transport only the concentrate to the old Potrerillos smelter.

Once more, then, a wholly new undertaking was launched on the barren desert. Temporary roads, water supply, power, construction housing, offices, and warehouses all had to be created before construction could begin. Once this phase of the program was passed and the heavy construction equipment had arrived, the $80 million project moved along with unprecedented speed and regularity to the start-up of the first units, just 20 months after the first concrete was poured. Here indeed the desert was transformed, not only by the metallurgical plant and its auxiliary buildings, but also by a carefully planned model town designed to house 7500 people in modern comfortable homes, with schools, churches, hospital, theater, shopping center and recreation facilities and all the modern utilities usually found in a town of this size.

There is no need to elaborate here the many engineering problems, or the innovations of design and construction at El Salvador, for these are covered in the following pages by the men chiefly responsible for its highly successful culmination. The entire project was completed within the cost estimate in less time than the scheduled construction period, and transition from construction to operation was achieved with minimum interruption.

PLANT CONSTRUCTION AND PROCUREMENT OF SUPPLIES

by STEWART CARPENTER
El Salvador Project Manager

Establishing a construction camp in so remote an area as the site of El Salvador project was initially as challenging as building the plant itself. Preparations included temporary installations of living facilities to accommodate personnel, electric power and water supply for both personnel and construction, communication lines, and conventional shops and warehouses. Suitable fine and coarse aggregate sources for concreting operations had to be found and developed.

Temporary quarters for the Chilean workers were of standard design with modern showers and toilet facilities. These *camarotes* accommodated 100 to 120 workers. One *rancho* or mess hall was constructed for every two *camarotes*.

The supervisory employes of single status were housed in similar *camarotes*. During the early stages of construction married supervisors were provided with housing for their families in Potrerillos, which was approximately 12 miles away and accessible only over circuitous roads in rugged mountain country. These men also stayed at the jobsite and visited their families in Potrerillos twice weekly. As permanent living quarters became available in El Salvador townsite, the families of the construction personnel moved into the houses earmarked for later use by Chilean workmen when the plant was ready to be turned over to operations.

Permanent buildings at the plantsite included the crushing plants; coarse and fine ore storage bins and conveyors; the concentrator—complete with rougher and concentrate thickeners, tailings thickeners, and disposal system; return water pumping station; molybdenum plant; concentrate pipeline to Llanta; 88-kv transmission line to Llanta; oxygen-hydrogen plant; milk-of-lime plant; reagent storage and handling facilities; and permanent shops and distribution systems for electric power, potable water, process water, and sanitary lines.

Permanent construction work also included installations away from the immediate plantsite, such as hydroelectric plant, various mine buildings and facilities at the mine, concentrate and construction material handling facilities at Llanta, and a complete permanent townsite.

In December 1957 a target date of April 1, 1959 was established for first operations. The first trainload of ore was dumped into the primary crushing plant on April 22, 1959. The target date was accomplished only by the combined efforts of many individuals and groups working closely together, although in some instances the groups were separated by as much as 5000 miles.

Anaconda-Jurden Associates Inc. of New York handled all the engineering design, requisitioned materials, and expedited delivery of materials to the jobsite. Liaison between the design office and the field was effectively maintained by airmail, cable, telephone, and personal contact. A continuous flow of information and materials to the jobsite allowed construction to proceed on an uninterrupted basis.

All requisitions for materials and equipment entering into the project were subject to review by the Chilean Government's Department of Copper to determine and advise what materials and equipment were manufactured in Chile and, in cases where they were not, to issue approval for purchase in other countries. Every effort was made to utilize Chilean materials—cement, re-inforcing steel, transmission tower steel, certain types of electrical wire and cable, pipe, and lumber were procured from local suppliers. Chilean officials cooperated to the fullest extent and readily approved procurement from other countries when there was any question as to availability, quality, deliveries, or price of material.

Import materials were transferred in lighters from ship to shore at Barquito, transported over the existing railroad to Llanta, and loaded into trucks and trailers for the final haul over the newly paved highway from Llanta to the jobsite. A gantry crane at Llanta transferred the materials directly from railroad cars to trucks.

Concrete was delivered to location in transit-mix trucks from a centrally located batch plant. A concrete-pipe plant also at the jobsite made all sewer pipe, and a modern concrete-block plant supplied blocks for houses, general store, hospital, and other auxiliary buildings.

As in most countries, certain standards governing design and construction, such as are applicable to housing, sanitation, and water supply, are required by law. Chilean representatives of the various departments regulating these standards were most expeditious in setting forth design requirements and approving plans and specifications.

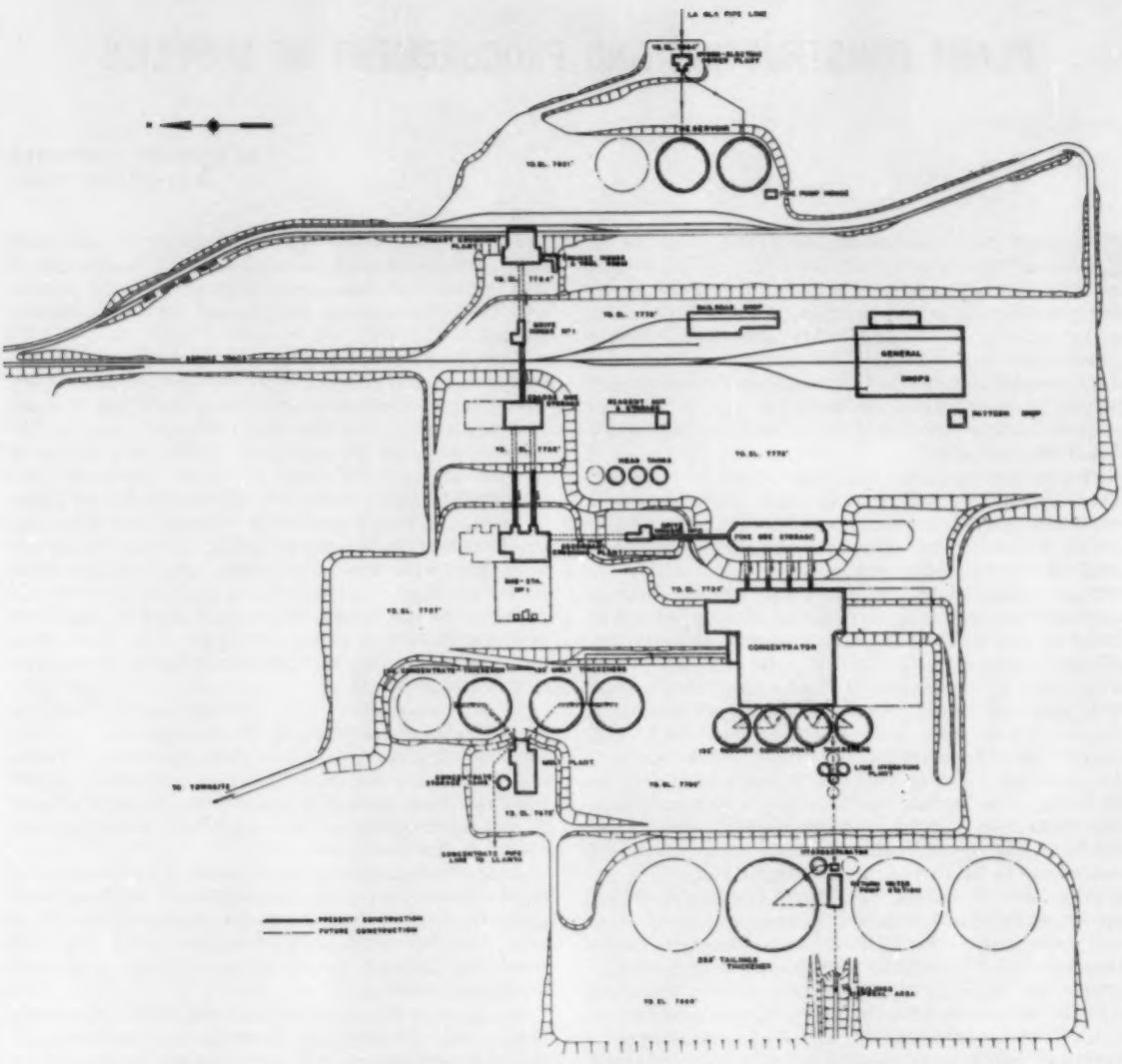
From the outset of the construction program, it was the company's policy to assign all field work to Chilean contractors and journeymen. A minimum group of overseas technicians, engineers, and supervisors scheduled the work and assisted the contractors.

Generally speaking, three types of contracts were awarded:

1) The administrative type of contract, as the name implies, was used chiefly for office work and other help where a fixed price could not readily be determined. Payments were made on a cost-plus-percentage basis.

2) Contracts for operation and maintenance of company-owned trucks, road graders, and other vehicles were individually set up because the intermittent use of equipment made it impractical to

GENERAL PLANT LAYOUT



Rail tracks lead from mine portal to primary crusher, upper left. Secondary crusher, left center. Concentrator, right center. Molybdenum plant, lower left.

establish fixed costs for this kind of work. Remuneration to the contractor was based on hourly rates established for each type of equipment.

3) The unit-price or lump-sum contract was awarded following analysis of comparative quotations on bids for specified work by two or more contractors. This type of contract was employed for all phases of construction: hand excavation; form work, including re-inforcing, concrete placing, and structural steel erection; and installation of roofing, siding, machinery, piping, and electricity. The contractor usually subcontracted to his workers on a unit-price basis. This gave the workers themselves an incentive to get the job done quickly.

Labor relations maintained throughout the construction period are a source of considerable pride. The entire job was accomplished without work stoppage and with a peak labor force of 4150 workers employed by 20 independent contractors.

An overall view of the complete flow of metallurgical operations—from primary crushing to final smelting—is provided by the sketches and captions on the next page.

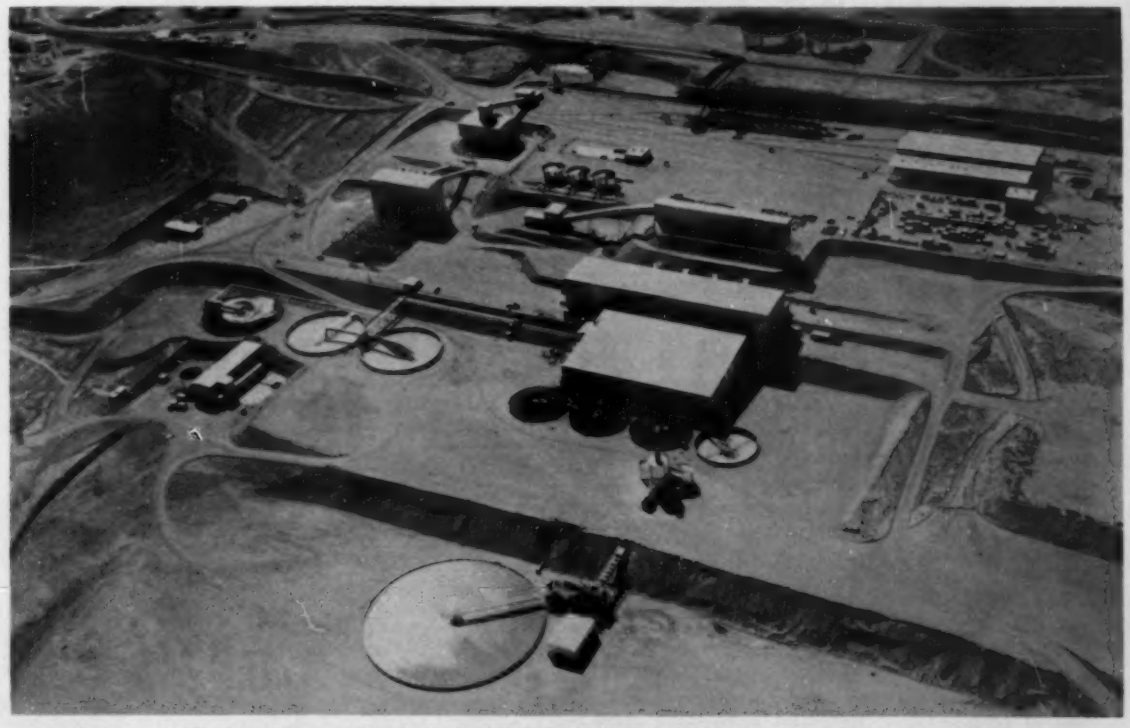
INTRODUCTION TO METALLURGICAL OPERATIONS

by **LEONARD O. FINES**
Assistant Manager,
Andes Copper Mining Co.

Metallurgical operations for recovering copper from El Salvador ores are divided between the new crushing plant and concentrator at El Salvador and the old filtering and smelting plant at Potrerillos. Concentrates are moved from the mill at El Salvador to Llanta by pipeline, then loaded into railroad cars and transported to Potrerillos.

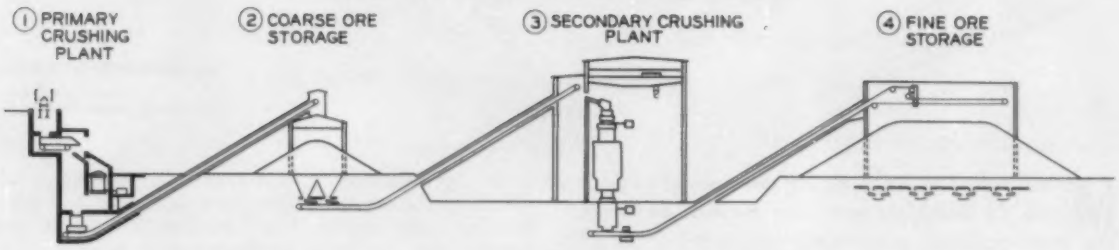
Mineralogy: Copper of 1.6 pct average grade occurs at El Salvador in the mineral forms of chalcocite (75 to 80 pct), chalcocite coating on pyrite (15 pct), and chalcopyrite (10 pct). Bornite and covellite are present in negligible amounts. Gangue minerals are principally quartz, anhydrite, feldspar, and alteration products. In general the copper minerals are finely disseminated among gangue minerals and require fine grinding for liberation and recovery. Molybdenum, a byproduct of substantial economic importance, occurs in the orebody as molybdenite. The friability of the ore indicated that the mine product would have a high percentage of fines.

Pilot Plant: Pilot plant beneficiation at El Salvador was conducted at Potrerillos for 20 months prior to plant operations. The principal objectives of this program were to train local personnel in operating techniques of the proposed process; to duplicate as nearly as possible the bulk flotation-regrind-cleaner-scavenger circuit that has become standard practice with Anaconda; to obtain advance information on the recovery of byproduct minerals such as molybdenum; and to test various reagent combinations for application in the final flowsheet. Since pilot plants are concentrators in miniature, the program proved decidedly beneficial.

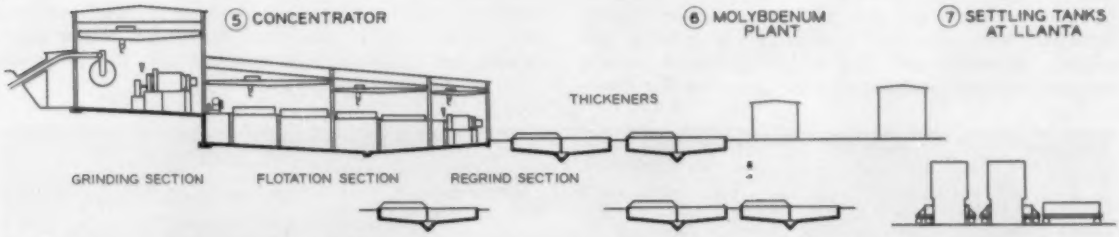


Aerial view of El Salvador metallurgical plant. Major units identified on accompanying general plant layout.

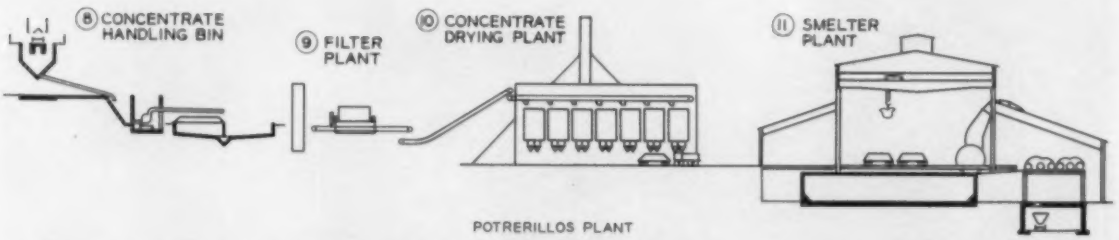
GENERALIZED FLOWSHEET OF MATERIALS HANDLING FROM PRIMARY CRUSHER TO SMELTER



Ore, hauled to the primary crushing plant by 40-ton bottom-dump cars, is dumped into unloading bins. The ore is drawn from the bins by four pan feeders and fed over grizzlies to two 30-in. gyratory crushers, each capable of handling 800 tph. The crushed product goes to two other pan feeders and onto a 54-in. belt conveyor which delivers it to the coarse ore storage pile. Vibrating feeders load ore from this pile onto two 36-in. belt conveyors which go to the secondary crushing plant. Here, each conveyor feeds a 6x14-ft vibrating screen. The oversize is fed to 7-ft standard cone crushers. This product goes to 5x10-ft vibrating screens and the undersize directly to the 60-in. belt conveyor. The oversize from the 5x10-ft vibrating screens goes to 7-ft shorthead cone crushers and thence to the 60-in. belt conveyor, which carries the product to the fine ore storage pile.

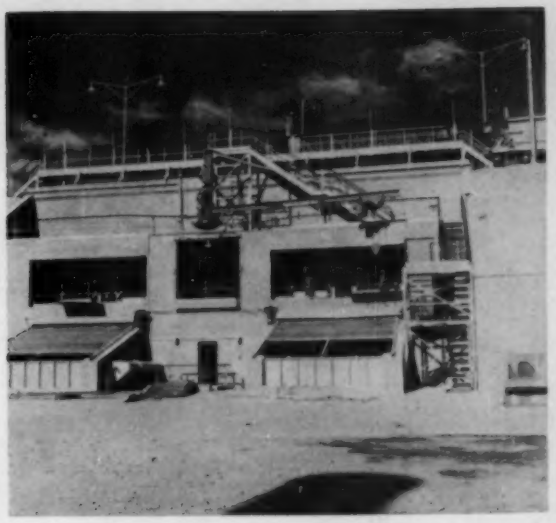


The 24,000-ton concentrator consists of four mill sections, each with one rod mill and two ball mills to feed the flotation circuit. The two ball mills are in closed circuit with a cyclone classifier. Pulp from cyclone overflow of each section passes to two rows of 28-cell machines for preliminary bulk flotation. There is one regrind mill for each of the four sections, each in closed circuit with five cyclones. The regrind mills grind the thickened product to 90 pct −325 mesh for cleaner-recleaner-scavenger flotation, and the scavenger and rougher tails combine to make the Final tail. Final cleaner concentrate is piped to the molybdenum concentrate thickener, where a cleaner-recleaner operation yields a floated product of molybdenum concentrate and a final cleaner copper concentrate to be piped to settling tanks at Llanta.



Concentrates loaded at the pipeline terminus at Llanta are hauled 40 miles to Potrerillos over the company's railway. The concentrate handling bin is divided into six compartments for simultaneous discharge of two rail cars. At the filter plant concentrates are dewatered to 11 to 13 pct moisture by four to five disc filters. The filter cake is dried to 6 pct moisture. At the smelter plant dried concentrates are discharged by hopper cars into a newly designed reverberatory furnace of 1000-ton capacity, which produces a matte grade of 60 pct Cu to feed the four converters. Copper produced by the converters is cast in 700-lb blister cakes.

CRUSHING PLANTS



by **EDWARD F. RAFFO**
Plant Layout Engineer,
Anaconda-Jurden Associates Inc.

The design of El Salvador's primary crushing facilities was determined by many factors. Early considerations were: 1) size and physical character of ore as received from the mine, 2) type and capacity of rail cars, and 3) elevation of the plant-site.

After passing through 18-in. grizzlies above the mine's underground loading bins, ore is hauled to the primary crushers in trains of fifteen 40-ton bottom-dump cars. Total haul from the mine covers three miles on a favorable grade of 3/10 of 1 pct, but only a half mile of this distance is surface haulage.

PRIMARY CRUSHING

To minimize dumping cycle requirements at the crushing plant, air-powered gate windup mechanisms were developed for the ore cars. Two cars are dumped simultaneously into unloading bins. Each of these two bins can accommodate a car length, and each has capacity for a half trainload. It will be seen that this arrangement serves another very important requirement in plant design.

It was anticipated that ore mined by the block caving method would contain wood and steel debris and a high percentage of fines. To provide picking facilities and grizzly area ahead of the coarse crushers, and also to economize and to allow for plant expansion, the primary crushing plant was designed on the basis of two identical units, each complete in itself and capable of handling 1500 tph. With fines running as high as 50 pct through a 6-in. grizzly, a 30-in. gyratory crusher of 750-tph capacity was chosen for each unit.

Under these conditions, the two units operating simultaneously can handle the total daily concentrator requirements of 24,000 tons during a single shift. The plan allows flexibility for initial production and for any expansion program up to or better than 100 pct, and by insuring continuous production during any relining program it reduces surge bin requirements between the primary and secondary crushing plants.

The two gyratory crushers are set up on a 40-ft centers parallel to the ore haulage track and unloading bins, offering an ideal arrangement for the layout of picking and grizzly equipment. Unloading bins are 38 ft long and 15 ft wide by 14½ ft deep. Ore is discharged from each bin through two openings, 5 ft wide by 4 ft long, onto two parallel 6x14-ft pan feeders operated by two-speed drives. These carry the ore transversely from beneath the bins to a picking station at the head end, where the feeders are automatically stopped and started as required. To avoid the excessive wear that would result from unloading cars into empty bins and to keep down abnormal dust, which would hamper picking operations, there are controls to prevent the feeders from running empty.

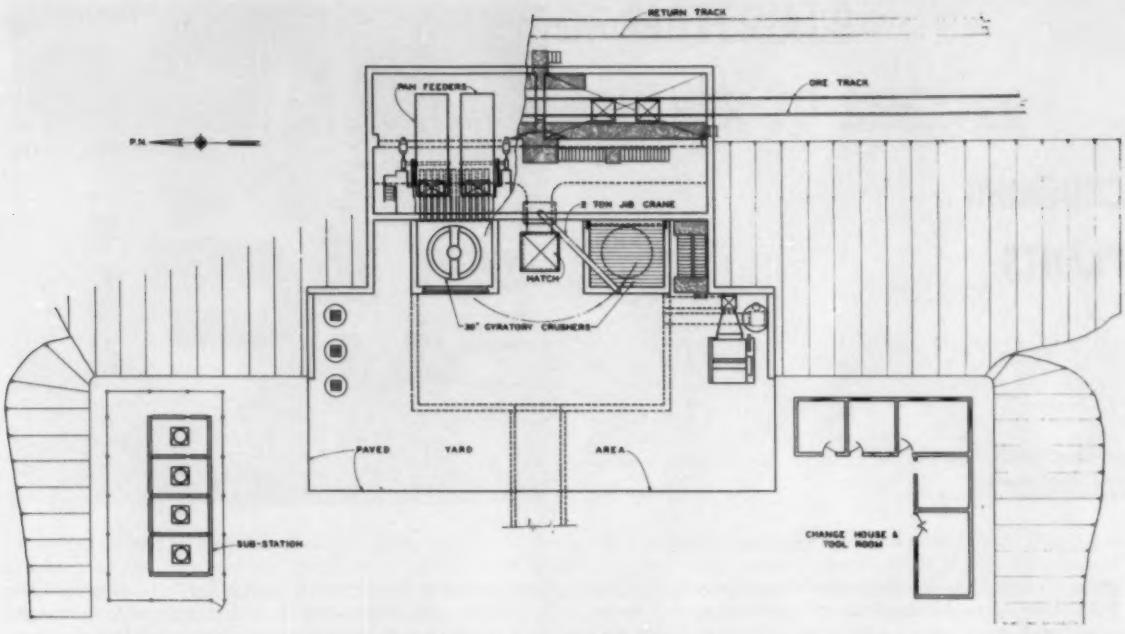
Use of the four pan feeders under normal circumstances permits a slow-speed, low-bed operation that lends itself to ideal conditions at the head of the feeder and is also conductive to good grizzly and crusher operation. Since work requirements for these feeders are relatively light, it was not necessary to install the usual heavy manganese type, which would have been more costly.

The 6-in. grizzly at the end of each pair of 6x14-ft feeders directs the oversize to the gyratories in such a way that most of the material spills on each side of the spider, which is oriented parallel to the material flow. The fines from each of the grizzlies and spill from the feeders combine with the −6-in. product of each single side discharge from the gyratories in a pocket with a 5x6-ft opening, which discharges onto two pan feeders 6 ft wide by 11 ft long.* From the pan feeders the product is carried by 54-in. belt conveyor to the 7000-ton coarse ore storage pile.

This single 54-in. belt conveyor (Conveyor No. 1) has a total horizontal length of 490 ft between tail and head pulleys. The total lift of 105 ft includes enough additional height at the head end to install a future transverse conveyor for expansion requirements. The lift has been minimized to some extent, however, by locating the coarse ore storage on a yard level 32 ft below that of the primary crushing plant. A magnet placed over the head pulley extracts any pieces of iron or steel debris too small to have been removed at the picking station ahead of the gyratory crushers.

The drive for this conveyor required 450 hp and

* These feeders are set an additional 6 in. above the floor to allow for possible installation of a manual or automatic pusher mechanism to dispose of spill to the discharge point of each feeder.



Plan of primary crushing plant.

was considered too large and inaccessible at the head end over the coarse ore pile. Therefore drive house No. 1 was located on grade at about the conveyor midpoint on one of the main plant yard levels. This structure houses not only the drive, which was developed as a dual arrangement, but also the gravity take-up, which is incorporated in the design. A 15-ton crane handles any component easily and efficiently.

COARSE ORE STORAGE

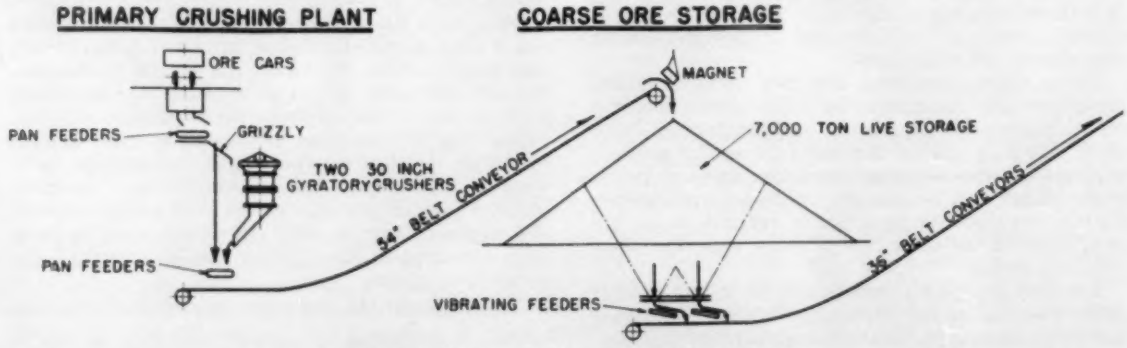
The coarse ore bin is essentially a 65-ft pile of ore acting as a surge between primary and secondary crusher operations. Diameter of the pile at yard level is about 175 ft, providing an active draw-off capacity of 7000 tons. A superstructure supported by columns, which extend through the inactive portion of the pile, covers the active area and houses the head end section of the conveyor from the primary crushing plant. Provisions have been made in design and clearances to install a bypass chute and transverse conveyor to feed an adjoining future pile.

The substructure, extending about 20 ft below yard grade, houses the collecting feeders and tail end sections of two 36-in. conveyor belts that haul the ore to the secondary crushing plant. Since the drawpoints above the feeders are only about 5 ft below yard elevation, the yard beneath the ore pile was graded gently toward these openings, making possible the recovery of nearly 14,000 tons of dead storage by bulldozing whenever ore requirements justify this.

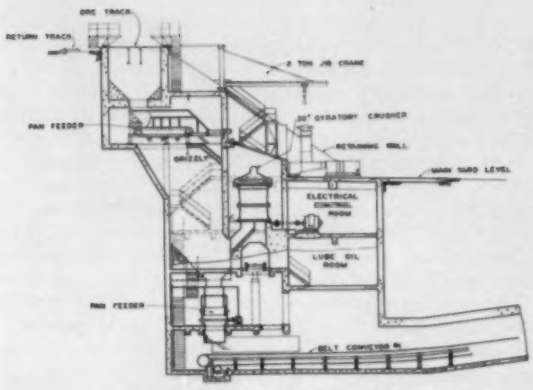
The two 36-in. conveyor belts are 335 ft long horizontally, with a vertical lift of 54 ft. They are driven by 100-hp motors located at the head pulley where gravity take-ups are installed.

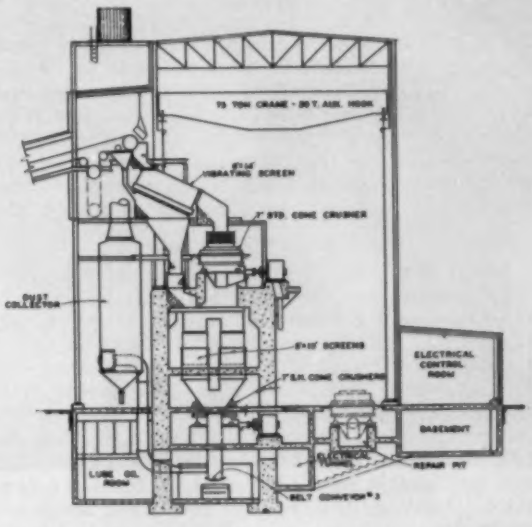
To obtain as much live storage as possible, ore is recovered from eight points in the storage pile by 4x6-ft vibrating feeders arranged in groups of four spaced 54 ft apart. Each of the two conveyor belts, serviced by a group of four feeders, carries ore from the pile to one of two identical crushing sections in the secondary plant. Production can be maintained by one belt with any two feeders in service, and each feeder can be manually adjusted to the feed rate required by the crushing unit.

No gates have been provided above the feeders because it was necessary to conserve head room and eliminate the need for platforms. In place of the gates, there are slots in the chutes to permit the operators to shut off the flow of ore by inserting rods or bars across the openings.



Flow of material through first stages of crushing plants.





ABOVE: Cross section through primary crushing plant.

RIGHT: Cross section through secondary crushing plant.

SECONDARY CRUSHING

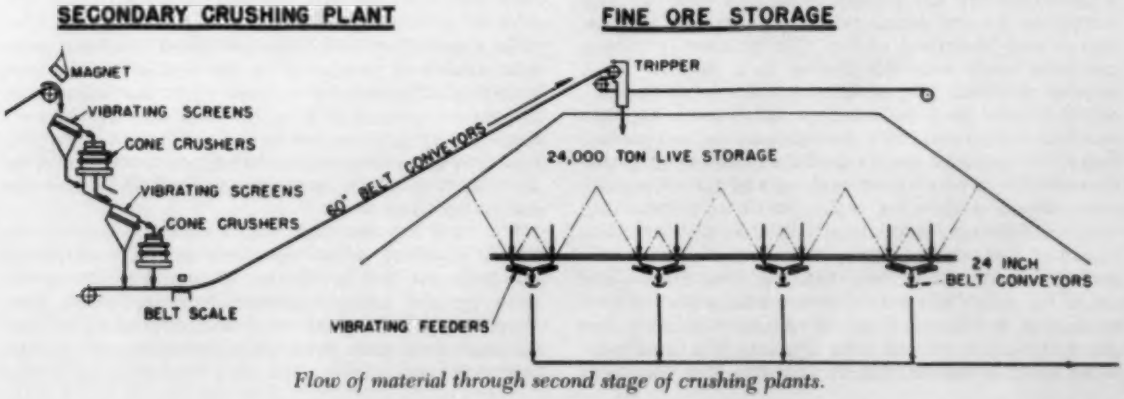
At each section of the secondary crushing plant one of the 36-in. conveyors feeds a 6x14-ft single-deck vibrating screen set to coincide with the centerline of the feed conveyor. The oversize feeds directly to one of the two 7-ft standard cone crushers; the undersize, in conventional open circuit, combines with the crusher product, which in turn gravity-feeds four 5x10-ft single-deck vibrating screens arranged in pairs on each side of the 7-ft crusher. The combined oversize from each pair of screens is again fed by gravity to a single 7-ft shorthead cone crusher which, with the shorthead crushers of the adjoining section, forms a line of four crushers at right angles to the conveyors from the coarse ore pile. The combined —⅝-in. product of the four shorthead crushers discharges to the 60-in. collecting conveyor below and is carried to the fine ore storage pile. Size of the product varies considerably owing to the fines and the shapes into which the ore crumbles.

An outstanding design feature of this plant is the location of the main floor level at the operating level of the shorthead crushers and the two repair stands depressed in the main aisle next to the operating units. Crusher drives are on the level below, accessible through removable hatches designed for truck loading. This arrangement makes for considerably more working area, eliminating the need for additional bays at the end of the building and reducing the overall height of the superstructure and standard cone foundations by 9 ft. This was particularly advantageous considering the earthquake potential of the area.

All process equipment in the plant is accessible to an overhead 75-ton crane and can be handled as a complete unit. This includes the 6x14-ft screens, which project far enough into the aisle to permit the use of slings if necessary.

Like the coarse ore bin, this plant has been designed to facilitate expansion. Crushing sections can be added, holding the same relative centerline dimensions, and the tail end of the collecting conveyor can be extended as required. The arrangement of auxiliary facilities and, in particular, the electrical distribution system, lends itself readily to expansion. The electrical control room is centrally located adjacent to and between the crusher aisle and the main plant substation. Main electrical distribution is made from the basement of the control room through a transverse tunnel connected to a longitudinal tunnel running the full length of the plant beneath the shorthead crusher drive motors. This tunnel system is also used in conjunction with the crusher motor ventilation system.

The belt conveyor (No. 3), which runs longitudinally beneath the shorthead crushers and the 5x10-ft screen undersize chutes, carries the crushed ore in an unbroken line up and over the fine ore pile for a total of 900 ft and requires a total lift of 125 ft, including the tripper at the storage pile. The 450-hp dual drive and gravity take-up are in the



Flow of material through second stage of crushing plants.

drive house, which is designed and located in the same way as the drive for conveyor No. 1. Conveyor No. 3 is 60 in. wide to accommodate ultimate plant capacity. The drive has been designed to handle only initial requirements, but for future expansion only one motor need be replaced. With the drive located in this way, the conveyor can easily be extended beyond the head end. A belt scale installed on this conveyor continuously measures and records the total plant production.

FINE ORE STORAGE

The 270-ft length of the fine ore storage pile, whose longitudinal centerline is parallel to the concentrator, was determined by the 60-ft spacing of the four mill sections to be served. The ore is distributed over the full length of the pile by a traveling tripper. Like the coarse ore supply, it is stockpiled at grade on a prepared sloping surface to permit salvaging the dead ore. The active or live capacity of the ore pile is rated at 24,000 tons, and the inactive remainder at 48,000 tons—a potential total storage of three days' production for emergency use.

To simplify construction and bulldozer operations, the superstructure housing the tripper gallery is supported by the fewest possible number of columns. This was accomplished by setting the columns transversely on 25-ft centers beneath the gallery and longitudinally on 60-ft centers between each of the substructure units that house the feed conveyors to the concentrator. The roof over the active portion of the pile is supported by cantilever construction.

Sixteen vibrating feeders deliver ore from the fine storage pile to the four 24-in. conveyor belts (4a-4d) traveling to the concentrator. These feeders are housed in four interconnected substructure compartments arranged in the same way described for the coarse ore storage. Although the compartments are 40 ft below final yard grade, considerably deeper than those in the coarse ore pile, the openings above the feeders are actually at about the same level as the original grade line, an advantage that minimized excavation and construction problems.

The concentrator is located on the downhill side of the fine ore storage pile. Assisted by gravity flow, the 24-in. conveyors carry ore directly to the feed end of the rod mills, requiring a total lift of only 20 ft in a total horizontal length of 210 ft. A belt scale on each conveyor records each mill section's operating rate, which may be varied by manual adjustment of the feeders.

DESIGN COORDINATION

Coordination of auxiliary designs was greatly simplified by the rectangular arrangement of basic equipment described above. The primary crushing plantsite itself was established in a shallow wash sloping at about 13 pct, where test exploration indicated excellent foundation conditions for the relatively deep structure. At this location and ground slope, ore haulage tracks could be aligned at grade elevation to a point near each end of the unloading bins which, with wing walls, serve as a retaining wall enclosure to support the feeders and grizzlies ahead of the crusher. Since the ground slope intersected the crushers near the top, the main yard could be established at this original grade and, if necessary, ore trucks could be unloaded directly into the crushers from the side opposite the grizzlies.

As design progressed it was obvious that the usual superstructure and crane runway over the crushers could be eliminated. A 2-ton rotating jib crane with a 30-ft boom located above the feeder platform on the centerline between the two crushers was installed for lining operations, disposal of wood and steel scrap, and other miscellaneous small lifting jobs. Eccentrics, drives, and other main yard equipment handled by crane can be passed through the 8x8-ft covered hatchway centered between the crushers and extending the full depth of the structure. The 250-hp crusher drive motors are in a single room, which houses all the electrical switchgear and controls just below yard grade.

To minimize costs and construction time, service and storage facilities were separated from the main building. Slabbing over the yard area immediately adjacent to and around the crushers created a natural repair center. In this clear, dry climate a roof and superstructure are not essential, but the arrangement lends itself readily to any type of future enclosure that may be thought necessary by the operating staff. For greatest convenience and simplicity a change room, lunch room, and tool room with adjacent storage area have been located along one side of the main yard, which is at a level about midway between the ore car dumping level and the conveyor tunnel beneath the crushers. The substation was located in the same yard, but opposite these facilities, in order to simplify the main electrical distribution system between the overhead feeder lines from the main substation to the control room beneath the yard slab.

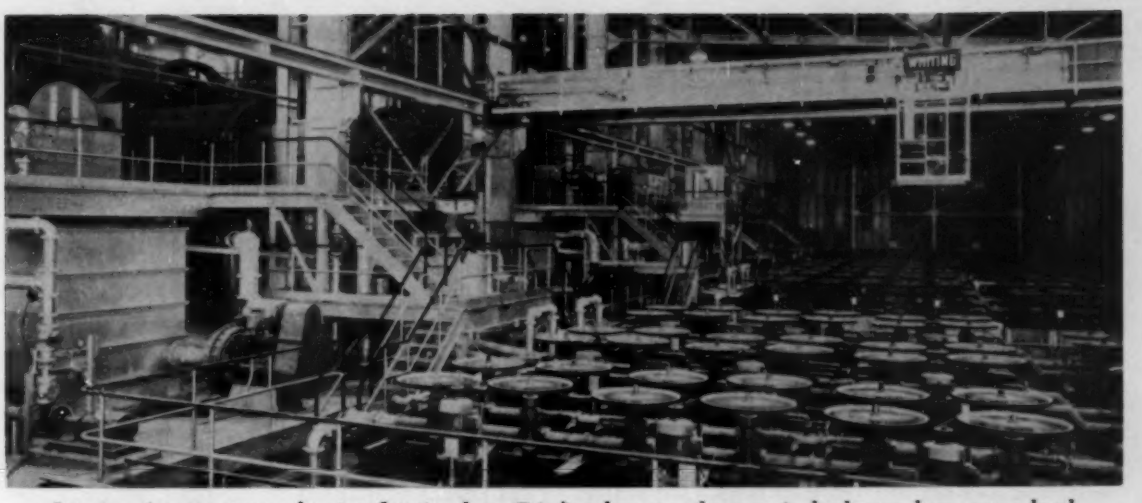
Dust Control: These facilities, discussed in greater detail on page 374, are also located apart from the main structure. In this case, the collector was situated at a lower yard level directly above the inclined conveyor tunnel leading from the depths of the crushing plant. This affords easy access to the unit for maintenance and minimizes the clearance problems, since the largest duct is carried in the tunnel and the smaller ducts are in the upper levels.

Roll-up doors, electrically operated on a 30° track, seal off the crushing operation for effective dust collection and control. Moisture in the ore is estimated to run normally at 3 pct, and there are sprays at the car dumping bins, feeder discharge, and crusher feed pocket. Provided the dust collection system is suitably adjusted, therefore, these doors can be partially opened for continual observation of the crushers during operation. Because the doors slope up and away from the truck dumping side of the crusher pocket, it is an easy matter to open them only to the extent necessary when feeding by truck or servicing from the yard level.

SUMMARY

In a period of 20 hr, the combined crushing units are capable of providing 24,000 tons of ore for wet grinding. Crushed ore is received in one coarse and one fine ore storage pile, of 7000 and 24,000 tons respectively, and carried by a combination of gravity flow and belt conveyors to the concentrator grinding section. Overall design takes full advantage of the natural ground slope.

Perhaps the greatest single design asset of the entire crushing plant flowsheet is the transfer of ore from one belt to another at storage points rather than by the usual conveyor transfer point, thus eliminating sources of wear and exposures to belt damage that are constantly troublesome to the operator.



Interior of concentrator showing flotation bay. Grinding bay may be seen in background on upper level.

CONCENTRATOR

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All three dimensions of the concentrator building are important to plant design. Depth is the most significant, to insure adequate hydraulic head for the fractions of ore flowing through the system by gravity.

DESIGN

Layout of equipment must provide flexibility and ease of handling for both installation and maintenance. Stairways and platforms, while held to a minimum, must be convenient for people to move about and adequate for local or minor repairs during operation. Areas must be set aside for storing assembled spare equipment, which is kept ready for immediate transfer into operation in case of major breakdown. There must be generous storage space for such expendable equipment as rods and balls and for parts to repair mill liners, pumps, blowers, and motors. There must also be ample space, conveniently located, for relining rod and ball mills and repairing motors, and extensive operating areas for the cranes, hoists, and lift trucks required to install and maintain equipment. If any one of these design aspects is ignored, both plant capacity and quality of the final product may be seriously affected.

The design of El Salvador's concentrator recognizes these considerations and includes several departures from conventional layout that are worthy of special mention, as may be seen in the flowsheet and accompanying illustrations.

It will be noted, for example, that there is no costly fine ore storage bin in the concentrator; fine ore is delivered and stored in a ground pocket behind the building. A concrete tunnel beneath this pocket houses vibrating feeders that regulate the flow of crushed ore to automatic-weighing belt conveyors. These in turn lead directly to the feed chutes ahead of the rod mills. Design and equipment of fine ore storage are detailed in the preceding article on crushing.

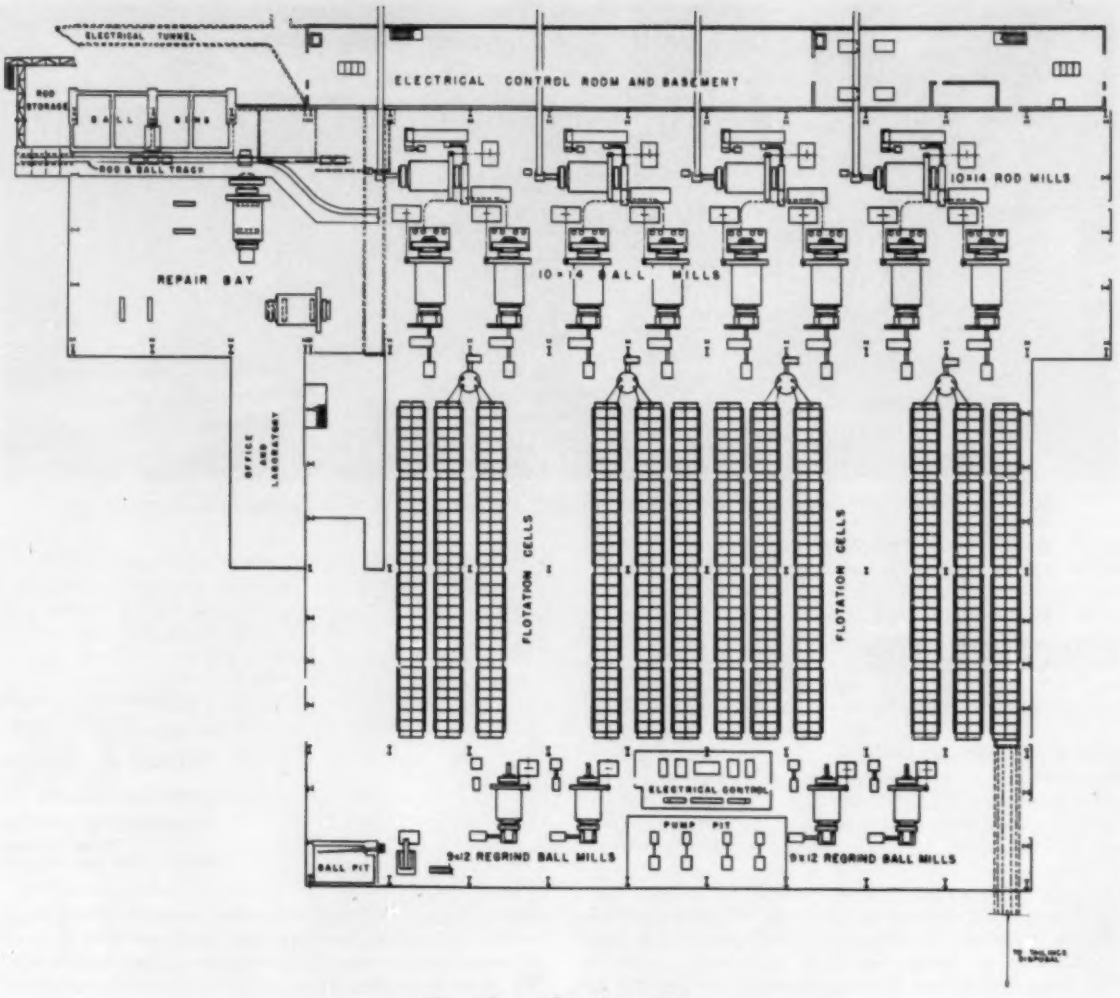
The 24,000-ton concentrator consists of four 6000-ton independent sections, each with grinding, flotation, thickening, and regrind facilities. Each is designed to handle a maximum flow of 7500 dry short tons per day but can operate at any desired feed rate. High-voltage power is distributed from the electrical control room and basement behind the grinding section.

For the sake of clarity, the operations of only one section will be described in the following paragraphs.

GRINDING

El Salvador's copper-bearing minerals are so finely disseminated that ore must be ground to flotation feed of 5 to 6 pct + 65 mesh and 60 pct −200 mesh. This fine-particle grinding is achieved, in each of the four sections, by one 10 x 14-ft rod mill in conjunction with two 10 x 14-ft ball mills. The two ball mills are in closed circuit with a cyclone classifier.

The compact arrangement of the four grinding sections has been accomplished by placing the rod mills at right angles to the ball mills. A four-hook overhead crane of 200-ton capacity installed in the grinding bay efficiently handles any one of these



Floor plan of flotation section.

mills; each pair of hooks can be lowered to the floor, where the sling thimbles can easily be slid over them. The crane is equipped with a 25-ton auxiliary hook for handling mill motors and other small pieces of equipment in the grinding bay.

The rod mill, in closed circuit with a 54-in. spiral classifier, is designed to handle a 25 pct circulating load. As ore is fed from one of the crushing plant's 24-in. conveyor belts, water and additives are introduced in the feed chute, which enters the mill through a specially designed seal within the feed trunnion liner. After passing through the rod mill, the ground product goes through a discharge box equipped with a perforated steel screen plate that traps broken or scrap pieces of rods. The box is so designed that the rod mill discharge can bypass the classifier, if necessary, to be evenly distributed to the two ball mills. A stationary rack holding a full day's supply of rods is placed next to a specially designed telescoping rod-charging machine in front of the discharge end of each rod mill.

Ordinarily the rod mill discharge flows to the 54-in. spiral classifier, which is fitted with a chip screen to keep wood splinters and other trash from circulating through the system. The classifier normally acts as a scalper, returning a small quantity of sand which is pumped back into the rod mill. Classifier overflow is evenly split and is piped to each ball mill feed sump, where it combines with the ball mill cyclone underflow. A combination double-scoop and drum feeder of 81-in. radius, designed to handle a 400 pct circulating load, is used on each ball mill to close the circuit between the mill and the four 20-in. wet cyclones. Grinding balls are charged from special cars through the drum section of this feeder.

The ball mill discharge goes to a trommel (oversize or refuse to a portable bucket) and from there to a constant-level sump. From the sump the product is pumped as feed to the four cyclones. Underflows go back to the mill and overflows to a junction box, thence through a sampler into a specially designed mechanical distributor.

Storage and Loading of Rods and Balls: Rods are stored outside the building in sand-bottomed bins with plate-lined walls. A 3-ton underhung crane with hoist and double magnet unloads them from a truck onto a specially designed rod car, which is hauled along a narrow-gage track, running the length of the grinding section, by the same battery-operated tractor that hauls the ball cars. Battery chargers for the tractor are conveniently located on the ball-charging floor.

The balls of different diameters are stored in bins, partly outside, for truck loading, and partly inside.

A magnet attached to a hand-controlled electric hoist operating on a monorail directly above the ball bins is used to load a charge hopper, which in turn empties an 8-hr ball charge for a single mill into small cars. Grinding balls are delivered from the charging cars directly to the ball mill through loading chutes on the centerline of each mill and these chutes in turn feed balls to the mill through the drum section of the combination feeder. Accurate ball and rod charging records are kept by an automatic recording track scale located on the charging track.

FLOTATION SECTION

Each of the four grinding units is followed by 112 cells consisting of four 28-cell machines, fed by a distribution box. Enough space has been provided at the end of each machine for addition of extra cells if the grinding section proves to have higher capacity than anticipated.

The cleaner-scavenger system, working in conjunction with the regrind mills and cyclones, has two rows of 28-cell machines, each machine arranged sequentially as follows: 6 cells of recleaners, 8 cells of cleaners, and 14 of scavengers. This provides a total of 168 flotation cells per grinding unit, all 48 in. square, with mechanical and air agitation. As much as 50 to 75 cfm is supplied at a pressure of 1.5 psi. The blower for each section is located below the tailings end of the flotation cells in the middle of the four units, and the discharge lines from the blowers feed directly to a continuous looped header. This arrangement permits more uniform air pressure, which is controlled by individual valves from the header to each machine.

Low-voltage power for the flotation cells is distributed from electric control rooms located in the basement directly below and in the center of each flotation section.

The concentrates from the rougher and scavenger cells of two sections are piped by gravity to a sump with three compartments, one compartment for each section and a third for a possible future standby pump. The combined concentrates from the rougher and scavenger cells in each flotation section are pumped to a rougher concentrate thickener. A design feature is the addition of a cyclone in this line to relieve the thickener of some of the load. Cyclone overflow goes to the thickener and cyclone underflow to a junction box, where it joins the thickener underflow and becomes part of the regrind mill feed.

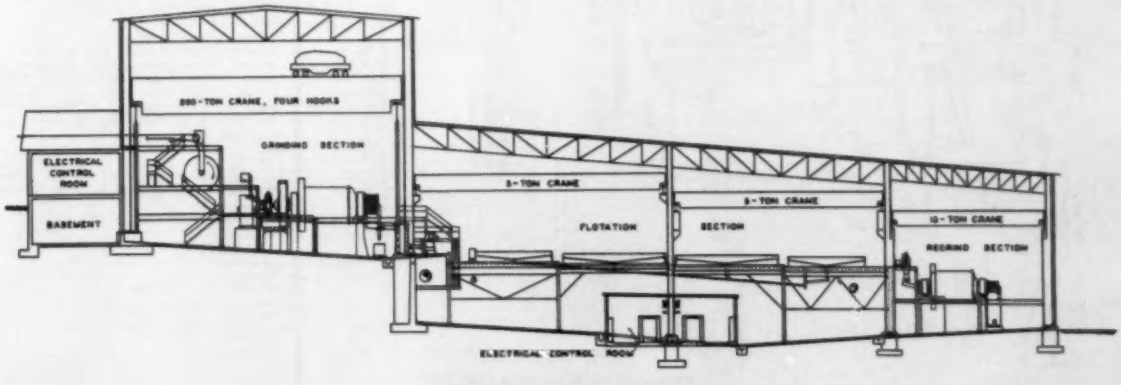
The combined concentrates from two adjacent sections of recleaner cells are also piped by gravity to a two-compartment sump, from which they are pumped to the molybdenum thickener north of the concentrator. Tailings are handled in much the same way, except that all flow is by gravity and the combined tailings are collected in a common sump.

Regrind Circuit: There is one 9x12-ft regrind mill for each of the four sections, each in closed circuit with five cyclones. Feed to the regrind mill comes from three sources: underflow from the five mill cyclones, via a junction box; underflow from the rougher concentrate thickener; underflow from the scalping cyclone on the feed line to the thickener. All this feed is collected in a chute that discharges directly to the regrind mill; the daily ball supply feeds into this same chute from a hopper. Discharge from the regrind mill is collected in a sump, from which it is pumped as feed to the cyclones to close the circuit. Cyclone overflow is collected in a launder and piped to a sump in the basement, and the 90 pct −325 pulp is pumped as feed to the cleaner flotation cells. Cleaner cell concentrates are pumped by a floor pump to the recleaner cells and cleaner cell underflow flows through the recleaner cells where the final concentrates are made. Recleaner tails flow in line directly to the cleaner cells and cleaner tails flow directly to the scavenger cells. Scavenger concentrates join the rougher concentrates for additional regrinding and the scavenger tails join the rougher tails as waste.

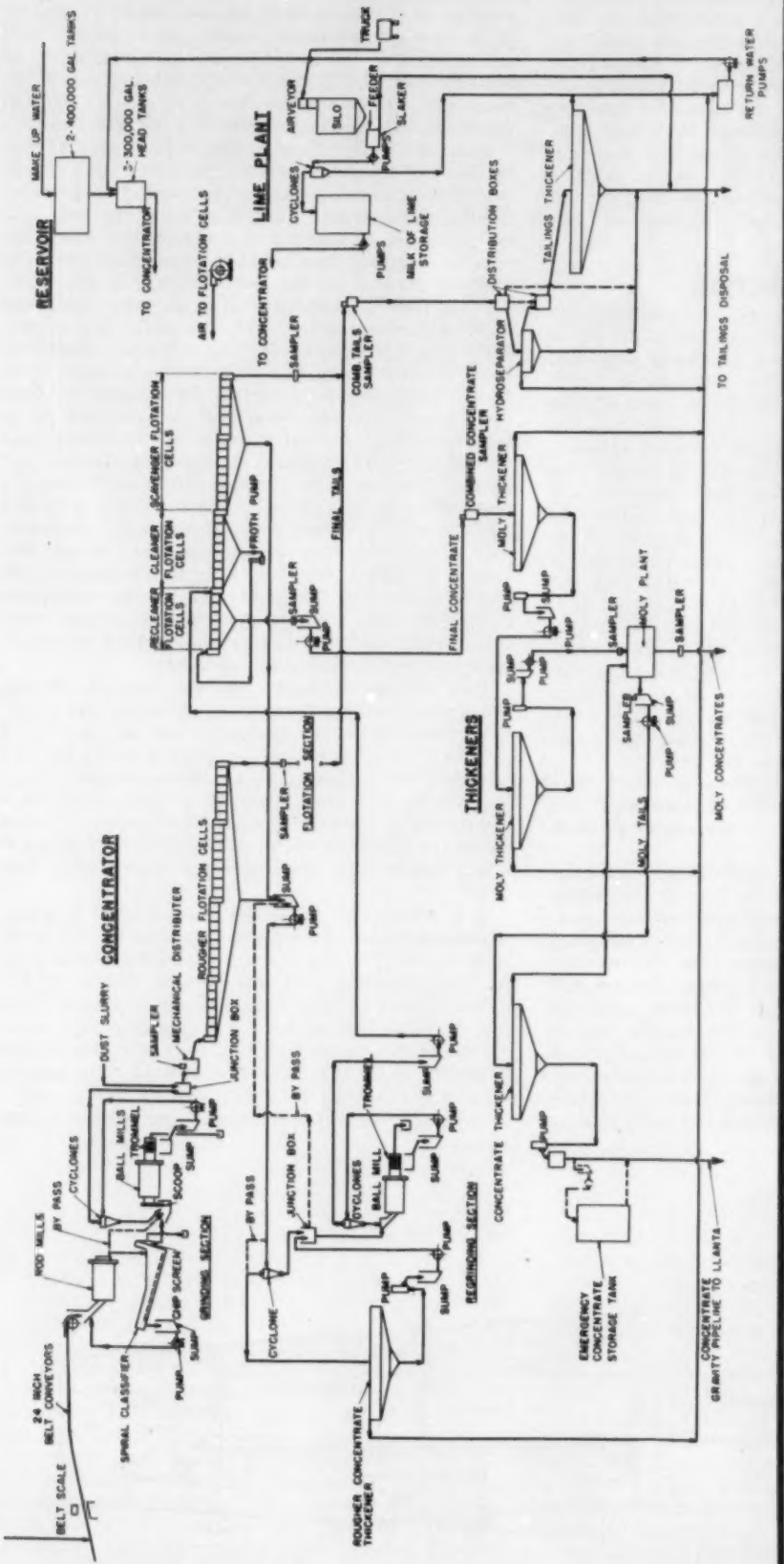
Ball storage facilities for the regrind circuits are similar to those for primary grinding, but handling differs from the storage point on. A magnet attached in a specially designed telescoping hydraulic crane is used to load a charge hopper, which empties an 8-hr ball charge for a single mill into a bucket set on a platform scale. The bucket is picked up by the overhead crane and the balls are dumped into a hopper that feeds into the regrind mill feed chute.

It is planned to reline the regrind mills in place, which cuts down the capacity required for the overhead crane. The telescoping hydraulic crane used for ball handling will also handle liners for the mills. When the trommel has been removed from the discharge end of the mill for relining, the boom on the crane can extend to the center of the feed trunnion. A foundation with a special sub-base for the crane has been provided at each mill.

The only area of the concentrator where it was



Cross section through the concentrator.



CONCENTRATOR PROCESS PIPING AND REAGENT FEEDING

Rod mill product is collected in a tank compartmented to permit gravity feed to either classifier or ball mill scoop box. The classifier circuit is closed by a sand pump discharging to the rod mill feed chute.

The ball mill product passes through a trommel into a cyclone feed sump, whence it is pumped to four 20-in. wet cyclones. Cyclone spigot product returns to the ball mill scoop box, and the overflow is piped to a junction box and then flows into a four-way distributor, which feeds four rows or rougher flotation machines.

Bulk concentrates are collected in four sets of flotation machine launders on each row of cells and thence flow by gravity to compartmented steel pump sumps so arranged that adjacent sections in the mill may use one common compartment. Concentrate from the scavenger flotation cells is collected in like manner.

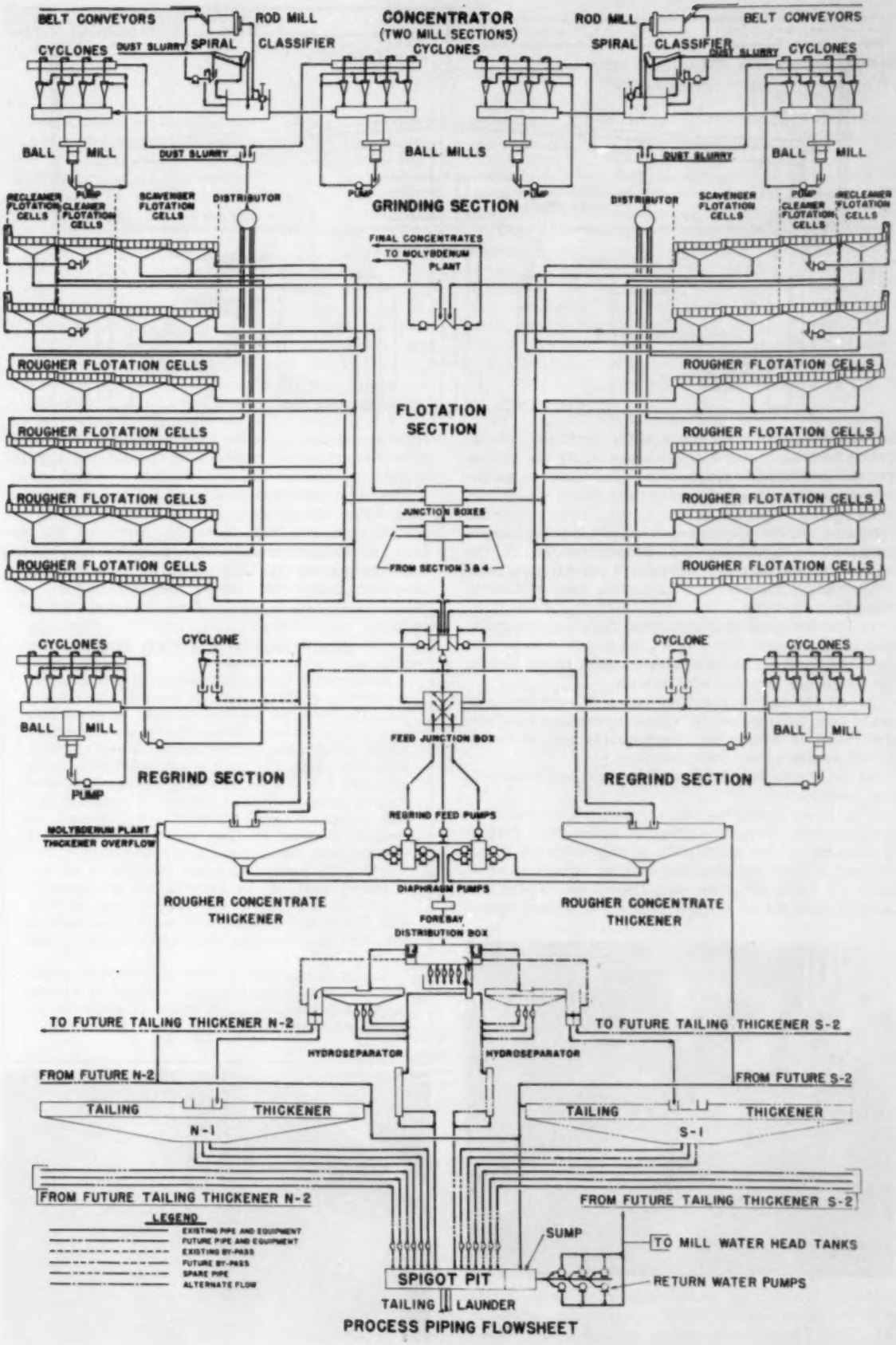
Bulk concentrates are pumped from the sump to the 100-ft thickeners provided for each mill section. The thickener feed can be bypassed over 20-in. wet cyclones to reduce the load on the thickener when large amounts of pyrite are present. The cyclone spigot is piped to the regrind ball mill feed chute with the overflow returning to the thickener feed line.

Underflow from the thickeners is controlled by duplex diaphragm pumps, set to discharge into the regrind mill feed pump sump.

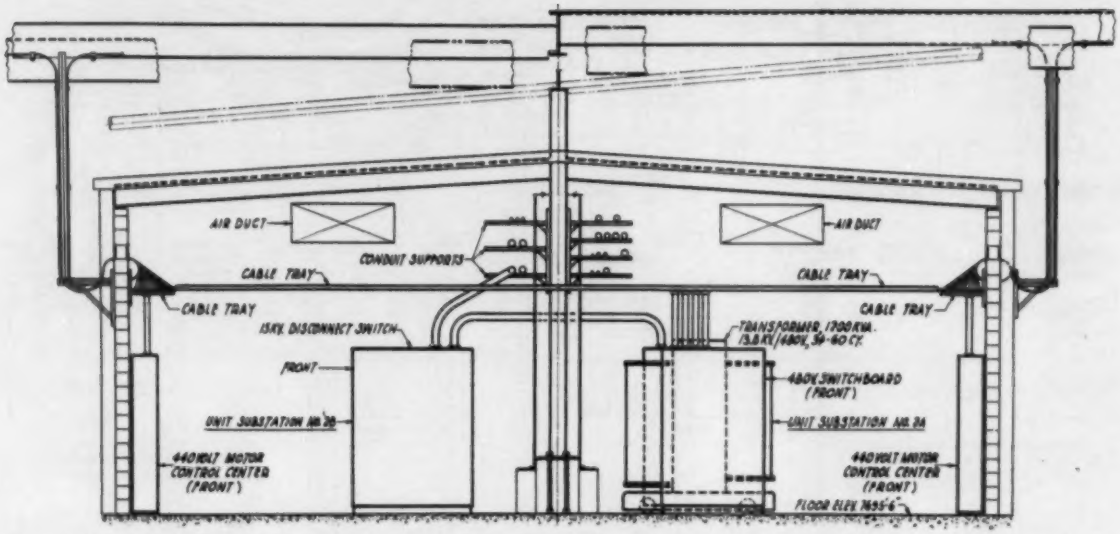
The regrind mill product passes through a trommel into a cyclone feed sump from which it is pumped to five 10-in. wet cyclones. Cyclone underflow is collected in a launder connecting to the mill feed chute. The cyclone overflow is collected in a sump and pumped to the two rows of cleaner cells. Cleaner concentrates drain by gravity to cylindrical sumps fitted with vertical froth pumps which lift concentrate to the head of two rows of recleaner cells. The recleaner concentrate collects flows by gravity to a sump fitted with a sand pump, which discharges to the primary wash thickener at the molybdenum plant where copper reagents are washed out.

Reagent flow from the manifolds to the distributors is controlled by solenoid valves actuated by adjustable timers mounted on a panel near the head tanks. The length of time the solenoid is energized to open the valve can be varied from one to one hundred percent of the 15-sec timing cycle. Adjustment of the flow rate with the valve open is controlled by a plate orifice. An indicating light on a panel gives a visual check.

The feed control system for milk of lime is similar to that for the reagents.



PROCESS PIPING FLOWSHEET



necessary to provide a pit is in the center of the regrind section where the concentrate thickener pumps and sumps are located. For ease of maintenance, all sumps and pumps are above floors.

Sampling: Special attention has been given to sampling for the operation. A very complete sample preparation laboratory has been provided on the end of the concentrator adjacent to the flotation area.

Wet pulp samples are taken at four places as follows:

1) At the head of the rougher flotation, for flotation feed sample.

2) At the final concentrates transfer pump sumps, for recleaner concentrates sample.

3) At the tailing junction boxes, for rougher and scavenger tailing sample. (Scavengers and roughers are taken at section No. 1 separately and are combined at the other three sections.)

4) At the tailing forebay, for combined final tailing sample.

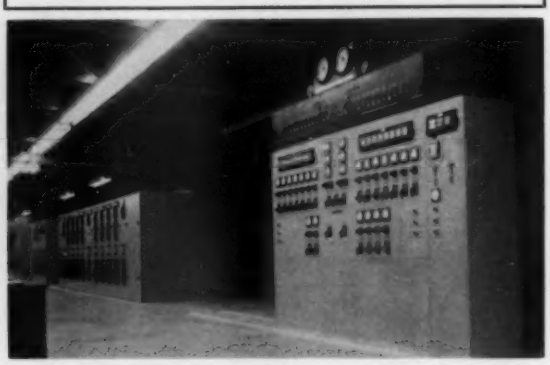
The basic sampling arrangement consists of a continuously operating primary cutter that diverts a fraction of the main pulp stream over an intermittently operated secondary cutter, which is actuated by limit switches and timers to reduce the sample to about 1.5 gal per 8-hr shift. Where rejects from the secondary cannot be reclaimed by gravity, they are returned to the pulp circuit by a small pump.

The electrical circuits are set up to permit stopping either the primary or secondary cutter in the pulp stream if desired. Normally, however, the cutters are stopped clear of the pulp stream by the limit switch circuits. Indicating lights advise operators of mechanical malfunction of samplers.

SAMPLING WITH PXQ UNIT

El Salvador has substituted an X-ray analysis, employing a PXQ unit, for its usual net assay methods for mine and concentrator samples. This is a direct reading X-ray fluorescence spectrograph called a Production Control X-ray Quantometer or PXQ. The unit is equipped with three channels for the simultaneous determination of copper, iron, and molybdenum. A scanning circuit permits determination of other elements as needed. Routine analysis for copper, iron, and molybdenum takes about 2 min per sample, less time than is needed to weigh the sample for wet chemical analysis. In general, the accuracy of the X-ray is equal to the wet chemical method. The X-ray unit is employed on a 24-hr basis so that mill operators can keep close control of the process.

Anaconda has done considerable work in establishing the feasibility of this method. A sample holder has been designed which presents an accurate reproducible sample, easily and rapidly.



ABOVE: Interior of control houses, flotation section. RIGHT: Main control board, concentrator substation. AT TOP: Typical cross section through control rooms.

MOLYBDENUM PLANT

by JEROLD S. OPKINS and IRVING HAUSER
Design Engineers, Anaconda-Jurden Associates Inc.

Preparation of Concentrate: Copper concentrate is pumped through 4-in. diam pipelines to a collection box ahead of the molybdenum thickeners. Each pipeline transfers the product of one concentrator mill section at a rate of 7 to 14 tph dry solids in a pulp that is 20 pct solids by weight and about 90 pct −325 mesh.

Since the molybdenite is floated and the copper is depressed in the molybdenum plant, any flotation reagents from the concentrator would be undesirable. The dewatering and washing operations, described below remove these reagents from the pulp.

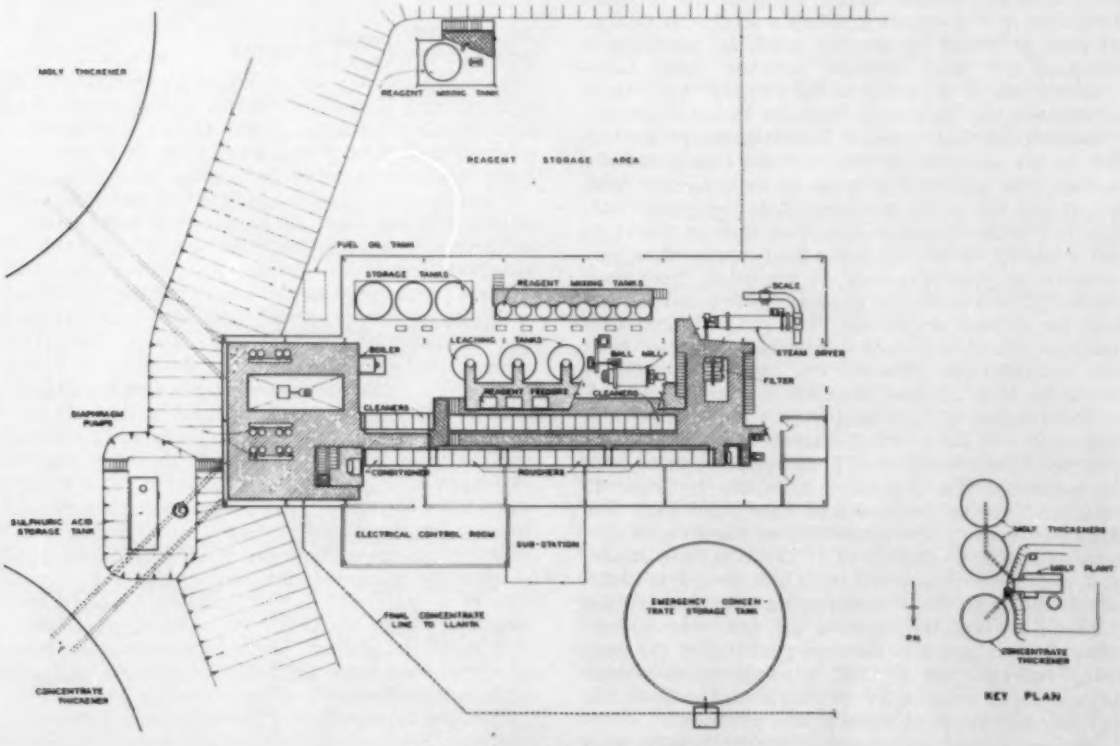
A distribution box directs the flow into the first of two 150-ft diam traction-type thickeners that are in series. Overflow from both thickeners goes by gravity to the plant's return water pump station to be reused in the mill water system. First thickener underflow, at 60 pct solids by weight, is withdrawn by diaphragm pumps in the molybdenum plant spigot house, where it is discharged into a sump and pumped back to another compartment of the distribution box. There the pulp is diluted to 20 pct solids with water from the plant service system and fed into the second thickener. After being sampled in the spigot house, underflow from the second thickener at 60 pct solids is ready for molybdenite extraction.

All piping is accessible. Maintenance problems are minimized by a trestle-carrying system and service piping to the thickeners and spigot tunnels from under the thickeners to the molybdenum plant. The design also permits bypassing the molybdenum plant process if desired.

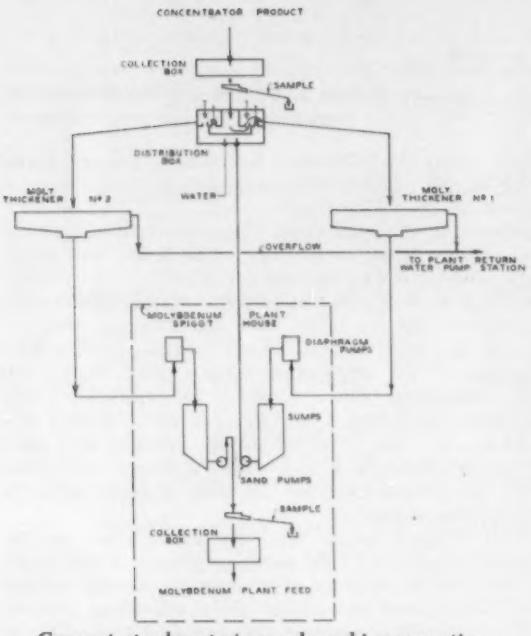
General Plant Layout: Equipment is located on three main levels in two bays. The larger bay measures 40x150 ft and the smaller 20x120 ft. On the operating level are the rougher and cleaner flotation machines, the cyclones, and the filtering and dewatering unit. Should the copper concentrator operation be expanded, space has been left for doubling the number of roughers and primary cleaners, installing larger cleaner machines in the final cleaning stages, and adding a leaching tank to handle increased capacities. All equipment needing continuous observation is on one floor level.

All reagent head tanks and feeders are on the feeder platform. This permits gravity feed to all points where reagents are necessary. Leaching tank agitator drives and openings to introduce reagent pellets to the leaching tanks are also accessible at this level.

All pumps other than the diaphragm, vacuum, and filtrate pumps are on the ground floor below the operating level. Products of all machines flow by gravity to the pumps and are elevated to the next step in the process. Other major items of equipment located on the ground floor include the ball mill, rotary dryer, reagent mixing and storage tanks, and steam boiler. All the large pieces of equipment are



Plan of the molybdenum plant.



Concentrate dewatering and washing operation.

accessible to overhead cranes. The main 40-ft bay is serviced by a 3-ton overhead crane, and the 20-ft bay by a 1-ton underhung crane.

Flotation Process: Most of the molybdenite separation takes place after the conditioner in the rougher flotation circuit, which consists of ten 48-in. 2-cell flotation machines divided into a 4-cell conditioning section, a 4-cell rougher No. 1 section, a 6-cell rougher No. 2 section, and a 6-cell rougher No. 3 section. All sections are in series and are separated by junction boxes. The principle of flotation used in this circuit involves a straight-line flow of pulp produced by gravity head. No pumping is required for pulp transfer between cells. Low-pressure air is supplied to all rougher cells by a centrifugal air blower to improve flotation results.

Dewatered and washed concentrator product is fed to the conditioner section where reagents are added. The conditioned pulp is then diluted with water and fed to the roughers. Here the copper sulfide is depressed and removed as tails at about 25 pct solids by weight while the float, removed as concentrate at approximately 20 pct solids from each section, is collected and pumped to the cleaner circuit for further separation. The molybdenum tails (copper concentrate) are sampled and pumped from the molybdenum plant to the copper concentrate thickener tank for final thickening.

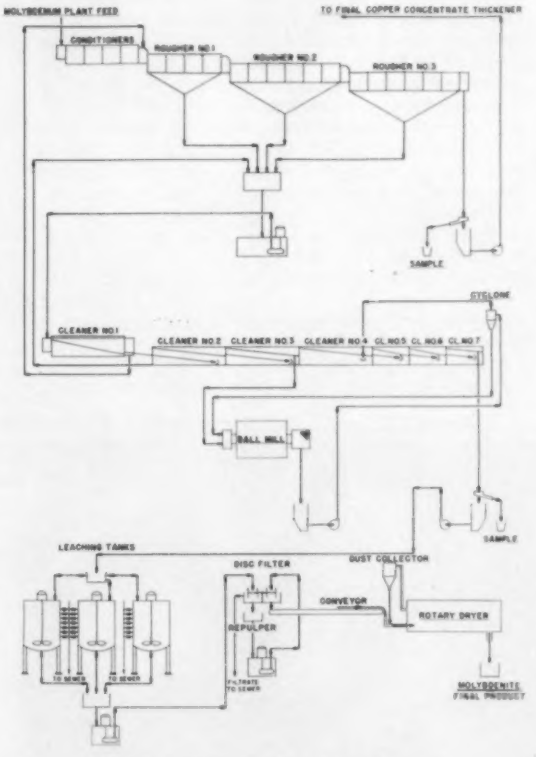
The rougher circuit float enters the cleaner circuit at cleaner No. 1, which consists of a 4-cell supercharged flotation unit similar in design to those used as roughers. The depressed tails are returned to rougher No. 1 to combine with new plant feed. The float advances to the remainder of the cleaner circuit—a flotation machine of 18 32-in. cells. Cleaners 2, 3, and 4 are each 4-cell units and Nos. 5, 6, and 7 are 2-cell units. Feed enters and passes through the machine by gravity, moving up and over an adjustable weir and into the feed partition of the next cell. Feed entering any cell is subjected to intense agitation and aeration by air that is sucked down the agitator standpipe at atmospheric pressure.

To insure finer separation in the final cleaning, a regrind circuit made up of a 4x8-ft overflow ball mill and two 100-mm cyclones in a closed circuit is employed in the process between cleaners 3 and 4. Tails in this 18-cell unit flow countercurrent to the float and are returned from cleaner No. 2 to combine with rougher float feeding cleaner No. 1. Final cleaner float at approximately 20 pct solids is sampled after leaving cleaner No. 7 and is pumped to the leaching tanks for further treatment. The 18 32-in. cells can easily be rearranged to change the number of cells in any of the cleaner stages.

Leaching Process: Three 9x10-ft steam-heated agitating tanks leach out any copper remaining in the final molybdenum concentrates and also thicken the final flotation concentrates ahead of the filtering step. A batch operation is employed. While one tank is being filled, a second filled tank is fed reagent pellets, heated, and agitated. After a period of time, the pulp in the second tank is allowed to settle and the clear solution on top is decanted via a manifold on the side of the tank. After further agitation to obtain a homogeneous mixture, the pulp is ready for filtering. While the first two tanks are filled and leached the third tank, which has already progressed through the first two steps, is drained at about 50 pct solids by weight to a sump, from which it is pumped to the filter. When the third tank is drained, it is filled again as the other tanks advance one step in the operation.

Filtering and Drying: The packaged filter and dewatering unit consists of a 4-disc continuous vacuum filter of 4-ft diam, a vacuum receiver, a wet-type vacuum pump, a filtrate pump, a repulper, and other accessories. A center partition divides the filter into two disc filters with a common shaft. Mechanical agitation and snap-blow air are provided to insure a drier cake and increase filter bag life.

The leached product is fed to the first filter com-



Molybdenite extraction flow diagram.

partment, from which the dewatered cake is discharged into the repulper. Service water is then added and the pulp discharges into a sump, where it is pumped to the second filter compartment. The final dewatered cake, containing approximately 15 pct moisture, is discharged onto a screw conveyor, which feeds into a steam tube rotary drier 3 ft in diam by 20 ft long. Dust created by the drying action is exhausted through a wet cyclone collector. Dried molybdenite containing about 5 pct moisture discharges from the drier into a drum in which it is to be shipped. The drum is vibrated to pack down the molybdenite and is pushed along a roller conveyor onto a scale for weighing. Drums are stacked until a load is ready for shipment.

Reagent Storage, Mixing, and Handling: Since large quantities of reagents are used in the molybdenum operation, storage for a three-month supply has been provided outside the plant. A forklift truck transfers the reagent drums into the building, where several days supply can be stacked. When mixing is necessary, an overhead crane with a drum tilting device picks up a reagent drum so that it may be directed to a mixing tank. Eight 4x4-ft mixing tanks and three 9x9-ft storage tanks are provided. Most of the reagents are mixed in 10 pct solutions and then pumped to constant head tanks on the reagent feeder platform. Others are fed as undiluted liquids directly to storage and thence to constant-head tanks located on the same platform. Flows from all the constant-head tanks are gravity-fed into pipe headers from which branches are taken at appropriate points to reagent feeders. The required quantities are then directed to their proper places in the flotation circuit.

The more volatile reagents are stored outside the plant in a 9x9-ft mixing tank with cooling coils. After cautious handling and mixing, the diluted reagent is pumped to storage tanks in the building to be fed into the process. Empty reagent drums are used to ship molybdenite.

Experience has shown that the operators may have to make several changes to the original flowsheet before achieving optimum production. For this reason the plant was designed and built with a maximum of flexibility. Changes, new equipment, or additions to original equipment can be easily made without seriously halting production.

CONCENTRATE HANDLING

by **JOHN P. MANNING**
Piping Engineer,
Anaconda-Jurden Associates Inc.

Concentrates produced at El Salvador are conveyed as slurry through a 14-mile pipeline to a railhead near Llanta where, after some decantation of water, they are loaded into special open cars for haulage by rail another 40 miles to the filter plant and smelter at Potrerillos.

History and Evolution: Transportation of materials in slurry form has been of increasing interest to Anaconda-Jurden engineers, who have compared data from various properties of the parent company and from any tests conducted to obtain design information for specific jobs. Whenever possible, the company's engineers have also inspected and reported on operating pipelines of other companies.

In addition, arrangements were concluded in June 1957 to have certain tests made at The Colorado School of Mines Research Foundation at Golden, Colo. For use in this testing program, 10 tons of concentrates were shipped from the Chuquicamata sulfide plant in Chile because the sizing and mineral composition of the Chuquicamata plant product most closely resembled that which would be obtained from El Salvador ore.

Although proven ore reserves at El Salvador were more than doubled by further geological exploration, it was decided to continue using the smelter and concentrator at Potrerillos. Investigations were conducted to find the most economical method for conveying concentrates from El Salvador plant to the smelter.

Among many methods considered were these:

1) Haulage by truck, either directly to Potrerillos or to Llanta for rail transhipment.

2) Pumping of slurry directly to the smelter.

3) Several combinations of gravity-pumping for conveying slurry to various points on the railway between Llanta and Potrerillos.

4) Slurry-conveying by gravity pipeline to a railhead 2½ miles east of Llanta.

The possibility of hauling by truck directly to Potrerillos was eliminated because it would have required a large investment in equipment and because maintenance costs on both road and trucks would have been excessively high. Haulage between the two places is about 25 miles over a mountain road with a succession of hairpin turns and steep grades.

A combination of truck haulage to Llanta and rail haulage from there to Potrerillos was initially considered more feasible. The loaded trucks would have been traveling on a constant downgrade over a paved road whose only steep grades and sharp curves occur in the relatively short distance where the road descends from the plateau immediately north of Llanta. But the chief advantage of this plan would have been offset, to a lesser degree, by the same drawbacks pertaining to the all-truck haulage scheme, with the added cost of rail transportation.

Pipeline descends the mountain at Llanta to deliver concentrate slurry to dewatering tanks shown behind burnt-lime storage bin in the foreground

Some thought was given to pumping thickened concentrates directly to the smelter, as this had been done successfully by several other companies, but preliminary investigation was sufficient to disclose several basic objections to this solution, any one of which was serious enough to eliminate it from further consideration. Costs of grading the terrain between the plants would have been prohibitive. The length of the pipeline would have been something like 20 miles, and pumps would have had to overcome a total dynamic head of 3900 ft of pulp. There would have been serious problems in providing access and power to one or more intermediate pumping stations, not to mention the high operating and maintenance costs for the pumps.

The staff at Potrerillos investigated possible alternative pipeline routes between El Salvador and several intermediate points on the railroad between Llanta and Potrerillos. They found that a gravity route could be obtained if the terminus were near Llanta. The length of pipeline in that case would be about 12½ miles, the rail haul to Potrerillos then being 40 miles. Two other possible routes were suggested, one about 20 miles and the other 8 miles. These routes would have intersected the railway 15 and 25 rail miles from Potrerillos, respectively, but both had the disadvantage of requiring pumping stations and of terminating far from any sources of power and other facilities.

The final decision was made in favor of the all-gravity flow route because it was recognized that the disadvantage of a longer rail haul would be more than offset by its simplicity and potentially low cost of operation.

Description of Pipeline: With one exception, the pipe used for this line is all 6-in., schedule-40, Dresser-coupled, plain-end, black steel pipe, aluminum-painted on the outside but with no interior lining. In the last section, where the line pitches down the side of a canyon at an average slope of about 40°, an operating and a parallel spare line are installed—both of 5-in., schedule 80, victaulic-coupled steel pipe—starting at a send-off box on the canyon rim and terminating at the head of the trestle leading to the distribution box at the storage tanks.

The head of the pipeline is in the molybdenum plant, where underflow pipe tunnels from three concentrate thickeners converge. Two of these thickeners are used to wash the mill concentrates free of copper flotation reagents before they are pumped to the head of the circuit in the molybdenum plant. The remaining thickener receives the molybdenum plant tailings, which are metered out by diaphragm pumps discharging into a box that feeds the pipeline. A sand pump taking suction from this box permits diversion of concentrates to an emergency storage tank that is sized to contain one day's production. Two means are provided to counteract settlement of solids while slurry is in storage; the tank is piped to permit 1) compressed air agitation and 2) closed circulation of contents through the transfer pump.

From the plant to the send-off box at the rim of the canyon about 12 miles away, the line slopes constantly downward, at 3 to 6.5 pct grade, in the direction of flow. It is estimated that the maximum it will carry is 650 gpm of 45 pct solids slurry. At the production rate of the initial plant it will flow only partially full, thus acting as a launder. The tests at the Colorado School of Mines Research Foundation indicated that the minimum rate of feed that could safely be introduced would be 40 gpm. Therefore, it appears that the line affords a large degree of latitude both as to quantity and density of its feed. No difficulty is anticipated from solids settling in the line once feed is cut off, because it is believed that these will either drain out or be picked up by the next feed introduced.

Except on the steeply sloping section near the end, the pipeline is supported either on small poured-concrete piers or on individual steel trestle bents whose legs were set in a base of poured concrete. The trestles were field-fabricated of either 4-in. or 6-in. pipe, depending on their height. Trestles are used on 20-ft spacing only where the depth of fill necessary to maintain the desired slope of the line exceeds 7 ft; otherwise concrete piers are used at the same spacing. The line is not anchored, but each length of pipe is strapped or U-bolted to its support. Changes of direction were made as sweeping curves by deflecting the pipe slightly at each coupling and, when necessary, by using short pipe-lengths. On the steep section where two parallel lines are installed, the support was made by inserting a commercial formed-steel section, of the type used for framing shelving in warehouses, into holes drilled in the country rock. Two vertical members were set and concreted in, with enough extension above grade to permit considerable vertical adjustment of the connecting cross member to which the pipes were bolted.

A steel sloping trestle 360 ft long carries the pipeline from the bottom of the canyon to the top of the receiving tanks, where it terminates in a distribution box. Each tank has capacity to receive slurry equivalent to 1000 tons of concentrates at 50 pct solids.

The settling tests made at the Colorado School of Mines had led company engineers to hope that these tanks would permit settling and decanting of excess water before the concentrates were loaded into the railroad cars. For this reason each tank has provision to locate the position of the layer of settled solids and

Construction of access road to area of pipeline location.

to decant the clarified liquid above that level, draining it to a settling pond where any contained solids can settle out and be reclaimed. A gasolene pump is installed there to provide high-pressure flushing water when that is needed to induce flow when the 8-in. valve in the tank discharge line is first opened.

On May 14, 1959, the engineering office was notified of successful start-up of the concentrate pipeline by a terse cabled message from the plant: "Concentrate into line 3:20 P.M., arrived Llanta 6:25 P.M." Without significant modifications the line has continued in satisfactory operation since that date.

The principal divergence between test work results and actual operations has been that the concentrate's rate of settling is greater than anticipated. The receiving tanks, for that reason, have not yet proved successful in their secondary function, which was to act as thickeners. No means was initially provided to agitate the tank contents, because test results had suggested that none would be needed and because it was believed that this could be taken care of later when behavior of the actual material had been studied. The operators are presently experimenting with various procedures. If none of these proves satisfactory, a pump may be tried that will maintain constant recirculation within the bed of settled solids to cure some initial difficulties encountered with plugging and discharging slugs of high-density material.

It is 65 ft from grade to the tops of the receiving tanks, which are 40 ft in diam. They are supported on circular concrete walls having openings that permit the train loading the wet concentrates to pass beneath them. Each of the 50-ton open rail cars which the plant has adapted from ore cars to haul the wet concentrates can be filled within a few minutes after it is spotted under a tank discharge line.

The concentrates loaded at the pipeline terminus at Llanta are hauled 40 miles to Potrerillos over the company's railway, which climbs about 5000 ft in that distance. At Potrerillos new unloading facilities have been constructed to accommodate simultaneous discharge from two cars. Opening the large dump valves at the bottom of each car rapidly discharges the bulk of the load, but a fire hose stream is needed to wash out the layer of fines that remains behind as a rubbery lining. Each bin compartment is separately valved. Drainage is through 6-in. pipes that lead to a common sump, from which a sand pump delivers the slurry to one of several thickeners at the filter plant.

SMELTER

by P. K. ALDOUS
Smelter Superintendent

To treat the maximum tonnage delivered from El Salvador concentrator, modifications and additions were made at the Potrerillos smelter. This article describes operations and equipment in the various sections before and after these changes.

Driers: The driers consist of seven 22-ft diam wedge-type furnaces, which were originally used for roasting. Drying reduces the moisture content in the feed from about 13 pct to about 6 pct.

Tramming from Driers to Reverberatories: Material from the drier plant discharge hoppers is trammed to the reverberatory furnaces in Koppel cars of 410-cu ft capacity. To speed unloading of concentrate into the reverberatories, the 10-in. diam discharge hoppers on the cars have been replaced by 12x12-in. hoppers.

Reverberatory Section: The original installation comprised three 115x21-ft furnaces in parallel, numbered 1, 2, and 3 from south to north. Sprung silica arches were used on all furnaces. For smelting El Salvador concentrates, No. 3 furnace has been remodeled. The front or slag-skimming end has been shortened by 10 ft and both side walls widened 1½ ft, resulting in new interior dimensions of 105x24 ft.

A new suspended arch using 15-in. tiles replaces the old silica-sprung arch. Plated and unplated magnesite-chrome brick are used for the smelting section, which extends 65 ft from the burner wall. The remainder of the arch, including the inclined section and boiler uptakes, is built of 15-in. suspended-type silica brick.

The proposed design called for connections to the No. 5 and 6 and No. 7 and 8 waste heat boilers, located respectively south and north of the slag skim bay at the front of the furnace. Shortening the furnace length made it possible to streamline and widen these flues, which are now in the form of a *Y* as opposed to the former *T* construction. In case of failure to either of these sets of boilers, a cross connection has been made from Nos. 5 and 6 to the adjacent Nos. 3 and 4 to assure full-scale operation at all times. Water-cooled dampers to fit the widened flues have been installed ahead of each set of boilers.

In addition to the suspended arches, No. 3 furnace has been equipped with cast-copper water jackets. These are in the burner wall in the front wall at the slag port and in the front end of the side walls extending halfway back towards the burner end. The fourteen 10-in. diam charge pipes on each side of the furnace have slides operated by air cylinders controlled from the charging platform above. All charge pipes have water-cooled copper collars, which are suspended in the basic arch. Unlike the arrangement in the old type of furnace, the chute returning converter molten slag to No. 3 reverberatory is located in the center of the suspended arch, 22½ ft from the burner wall. This too is water-cooled at the entrance to the arch. Four water-cooled matte taps on both sides of the furnace are connected by inclined copper launders leading to pits that have been enlarged to accommodate the new 210-cu ft ladles.

Another significant change has been the installation of a high-pressure fuel oil system. Pressure is maintained at 250 psi, with oil preheated to 240°F and primary air at 6 psi.

Cranes: Under the old system, two 60-ton overhead traveling Morgan cranes serviced the reverbs and converters. Each crane had two 60-ton hooks with one 10-ton auxiliary hook centrally spaced between them. The old carriages have been replaced by new trolley assemblies, each comprising one 75-ton central hook with two 10-ton auxiliary hooks equally spaced on each side. New air-conditioned operators' cabs hang from the center of the original bridges.

Ladles and Bails: To handle the increased volume of matte commensurate with larger tonnages to the reverberatory furnace, five cast steel ladles of 210-cu ft capacity have been purchased, to date, to replace the earlier 115-cu ft ladles.

Converter Section: This section comprises four Pierce-Smith 12x26-ft converters in conjunction with two 8x18-ft cylindrical receiving furnaces and two straight-line casting machines with 42 molds apiece. For crushing converter cleanings, clean-up, etc., there is a unit at the south end of the aisle, comprising a bin and a 15x24-in. Blake-type crusher in circuit with a 16x36-in. set of rolls.

The following major changes have been made in the converter section:

Supporting front columns and converter hoods have been widened to accommodate the larger ladles.

It is proposed that the existing 1½-in. tuyeres be replaced by tuyeres of 2-in. ID to speed up converting time. This will necessitate remodeling the present air connections and enlarging the bustle pipes. These changes have not yet been made.

The old method of charging flux and cold dope to the converters using crane and boat has been eliminated by the installation of automatic feeders to each converter. There are now movable self-discharging cylindrical buckets of 16-ton capacity on the elevated platform on both sides of all four converters. These buckets supply 1½x6-ft electric vibrating feeders, each having a capacity of 3 to 40 tph, which are controlled from the operator's platform below. Vibrator discharge falls onto a retractable steel chute protruding through the side of the hood directly above the converter mouth. The chute is advanced and retracted by an air-operated cylinder of 6-in. diam x 56-in. stroke.

To store cold dope, a duplicate bin of 300-ton capacity has been built adjoining the north side of the existing silica flux bin. Material from these bins is discharged via arc gates operated manually through a pulley and counterweight system into movable chutes, which in turn feed the 16-ton buckets set in pits in front of the bins.

Casting Machines and Copper Dock: It was necessary to speed up the casting of blister copper cakes in order to cope with increased tonnage from the converters. Larger copper molds were cast for use on the straight-line casting machines, and the original 300-lb blister cake has been replaced by a 700-lb cake of new design, with lugs on both ends for easier handling.

Forklift trucks with remodeled forks have replaced the old platform trucks. A 5-ton overhead traveling crane, traversing the entire dock, is used to load railroad cars and weigh the blister cakes.

SUMMARY OF

METALLURGICAL OPERATIONS

by LEONARD O. FINES
Assistant Manager,
Andes Copper Mining Co.

Ore from El Salvador's block caving operations is reduced to −6 in. by two 30-in. gyratory crushers. After the undersize has been screened out, the remaining material is further reduced to −⅝ in. by two secondary standard cone crushers and four tertiary shorthead cone crushers. Four 24-in. belt conveyors, assisted by gravity flow, transport the ore directly to the feed end of the rod mills in the concentrator's grinding units, which produce a flotation feed of 5 to 6 pct + 65 mesh and 60 pct − 200 mesh.

The concentrator comprises four 6000-ton mill sections, each consisting of one rod mill and two ball mills. The ball mills are in closed circuit with cyclone classifiers.

Pulp from the cyclone overflow of each section passes to two rows of 28-cell machines for preliminary bulk flotation. The milk of lime modifier is added to the rod mill ahead of flotation for proper mixing. A small amount is also added in the regrind mill to maintain the same alkalinity in roughers and cleaners. Collectors are used with pine oil as a frother, and provisions are made for stage addition of collectors and frothers to various parts of the flotation circuit. Froth from the bulk and scavenger flotation is thickened prior to regrind.

Four 9x12-ft regrind mills grind the thickened product to 90 pct −325 mesh for the cleaner-recleaner-scavenger flotation, and the scavenger and rougher tails are combined to make the final tail. Final concentrate runs 45 to 50 pct Cu, which is conducive to production of high-grade matte for economical smelting.

The final cleaner concentrate is piped to a molybdenum concentrate thickener, where a cleaner-recleaner operation yields a floated product of molybdenum concentrate and a tailing of final cleaned copper concentrate ready for pipe-tank-rail delivery to the smelter at Potrerillos.

The final tailing, which consists of dewatered bulk and scavenger tailings of 45 to 50 pct solids, is sent to the tailing disposal area through a lined canal. All thickener overflow water, together with concentrate thickener overflows, is returned to the concentrator head tanks for re-use in grinding and flotation circuits.

A 12.7-mile pipeline carries the final cleaned copper concentrate pulp from El Salvador to a railhead 2.8 miles above Llanta, where it is received by two 40x25-ft settling tanks, each provided with a still well. Each tank has a capacity of 1000 tons of concentrate. The slurry, after settling for a short period of time, decants at approximately 70 pct solids. Decanted water is removed to sump ponds through pipes at various levels on the side of the tank. The thickened pulp is discharged by spigot into railroad cars provided with splash plates to prevent spillage during transport. Each car has six bottom-discharge doors.

The loaded cars are hauled by diesel locomotive to the Potrerillos handling bin, which is divided into six separate compartments so that two cars of slurry can be discharged simultaneously; these compartments are also necessary to minimize hang-up and packing. The concentrate cars are hosed down after discharge. The concentrate slurry is repulped by a pump before being transferred to a series of four thickeners.

Filtration of thickener discharge is accomplished on four to five 12x14-ft disc filters. Cake is produced at a thickness of ⅝ to ¾ in., with moisture from 11 to 14 pct.

Concentrate is conveyed to wedge-type roasters, where it is further dried to 6 pct moisture. The dried concentrate is loaded into hopper cars and trammed to a newly designed reverberatory furnace of 1000-ton capacity. This magnesite and silica suspended-arch furnace produces a matte grade of 60 pct Cu to feed the four 12x26-ft converters. Copper produced by the converters is cast in 700-lb blister cakes.

Equipment at the Potrerillos smelter has been modified and enlarged to handle an anticipated copper production of about 200 million pounds a year.

Some results obtained in the flotation circuit are tabulated below:

Tons of ore treated at concentrator	18,000
Alkalinity of feed to flotation, pH	11.5
Consumption of burned lime per ton of ore, lb	4 to 5
Feed to flotation:	
+65 mesh, pct	7 to 9
−200 mesh, pct	60 to 65
Feed to cleaner circuit, −325 mesh, pct	90 to 95
Total copper in feed, pct	1.60 to 1.80
Total copper in final cleaner concentrate, pct	48 to 55
Insoluble in final cleaner concentrate, pct	5 to 7
Sulfur in final cleaner concentrate, pct	25 to 30
Total copper in scavenger tailing, pct	0.5 to 0.6
Total copper in rougher concentrate, pct	20 to 24
Total copper in final tailing, pct	0.18 to 0.20
Leach copper in final tailing, pct	0.06 to 0.08
Tons of concentrate per day	600

DUST CONTROL, HEATING, AND VENTILATION

by WILLIAM S. PEDERSEN

Fume and Dust Control Engineer
Anaconda-Jurden Associates Inc.

The dust control systems at El Salvador were treated as belonging to the crushing and conveying processes and were designed as integral parts of the plant, rather than as auxiliary units.

Collectors of the wet fan scrubber tower type were chosen because their efficiency is relatively high and because the collected dust can be easily disposed of in the concentrator mill circuit. This type of collector was installed throughout the plant except at the outdoor dumping pocket, where it was decided to use water sprays, as hooding was impractical. Rather than a large central collecting system for each plant, the dust control systems were unitized to correspond to the grouping of plant equipment as shown for the secondary crushing plant in the illustration on page 374A. This arrangement offers flexibility for future expansion; simplifies maintenance, as the dust control system is in use only when its associated equipment is operating; and minimizes the difficulties of balancing each part within a complex system. The principle underlying this arrangement was also followed in the system designed for the concentrator laboratory, where it was desirable to keep heated make-up air at a minimum and, at the same time, to provide adequate exhaust capacity.

Dust load per cubic foot (grain loading) in the entrained air was kept low to avoid either accumulation of dust or excessive wear in the ducts. Skirtboards at conveyor loading points and intake hoods at exhaust points were designed for velocities of 500 fpm.

Ducts were sized for a velocity range of 2800 to 3300 fpm to minimize the use of balancing dampers. All necessary dampers were of the plate type, bolted between flanges at the initial balancing.

Grain loadings were based on actual data obtained from a similar operation in Chile which showed that the loadings increased considerably as the ore went through successively finer stages of crushing. The figure used for first stage of crushing was 2 (grains). This was increased to 5 grains at the last stages.

All ductwork, including elbows, was fabricated in Chile of 3/16-in. black steel plate.

A total of 120,000 cfm of air is exhausted from the ore-crushing and handling circuits. In addition 28,000 cfm of air is exhausted by the dust collecting and fumes exhaust systems in the concentrator laboratory.

A breakdown of air quantities by principal buildings is as follows:

Location	Air, Cfm
Primary crushing plant	One system at 35,000 cfm
Coarse ore storage	Two systems at 8,400 cfm each
Secondary crushing plant	Two systems at 35,700 cfm each
Fine ore storage	Two systems at 14,400 cfm each

Primary Crushing Plant: As no superstructure was contemplated for the primary crushing plant, it was apparent that some dust control method other than the conventional exhaust system would have to be used for the dumping pocket. A water spray system was chosen because: 1) the use of manually controlled hopper-bottom ore cars and a short ore drop would mean that the displacement of air from the pocket would be gradual, and 2) moisture would be added to the dry ore, which would help to minimize the dust throughout the ore-handling circuit. The system consists of spray nozzles located so that the spray completely covers the dumping pockets. They are controlled manually by the car-dump operator.

In addition to the spray system at the dumping pocket, this plant also has a conventional exhaust system to control the dust generated by the mechanical equipment in the substructure. A breakdown of the previously tabulated exhaust air is as follows:

1) 5500 cfm from the pocket above each of the two crushers.

2) 6000 cfm from each of the common pockets forming the pan feeders dribble chute, the fines chute, and the crusher discharge pocket.

3) 3000 cfm through four intakes from the enclosure around the two pan feeders loading the conveyor to the coarse ore bin.

4) 9000 cfm from the feed chute and skirtboard enclosure at the loading point of the 54-in. conveyor to the coarse ore bin.

Secondary Crushing Plant: Each of the dust control systems in the secondary crushing plant exhausts air from the head chute at the incoming conveyor discharge, the screen to the standard cone crusher, its fines chute, the standard cone crusher, the crusher discharge pocket, the four vibrating screens feeding the shorthead cone crushers, their fines chutes, and the skirtboard enclosure at the feed points to the outgoing 60-in. conveyor.

Ore Storage Bins: Dust is controlled at the ore bins by exhaust connections in the substructure at the skirtboard enclosure where the vibrating feeders draw off the bins and load the conveyors.

The coarse ore storage bins dust control consists of two systems exhausting 8400 cfm from four vibrating feeders, the conveyor loading chute, and the skirtboards.

The fine ore storage dust control systems handle the same type of equipment, but of smaller size, with 14,400 cfm for eight vibrating feeders and two conveyor loading points.

Concentrator: The only dust control provisions for the main mill equipment in the concentrator are the sprays at the head end of the four conveyors where the ore is fed to the wet rod mills.

The sample preparation laboratory in the concentrator is serviced by 16 dust control and fumes exhaust systems. Great care had to be exercised in unitizing these systems, not only to keep the make-up air to a minimum, but at the same time to have the necessary exhaust systems operating in conjunction with the laboratory procedure. This was achieved by interlocking the exhaust system hood light with the fan so that the exhaust system is in operation only when the hood is being used.

Two heating and ventilating units continually supply filtered make-up air equal to the largest quantity exhausted at any time.

HEATING AND VENTILATION

The heating and ventilating systems at El Salvador for offices, change rooms, and laboratories are designed to maintain inside temperature of 70°F with an outdoor minimum of +30°F. At the site elevation of 7400 ft, the climate is very dry and relatively mild, but there is a wide daily temperature range because there are seldom any insulating cloud layers.

Minesite: The mine change house, staff change house, safety and ventilation office, and time office are provided with heat. The boiler room, located in the mine change house, contains a package type of light-oil-fired hot-water boiler. The primary circulator, which pumps 200°F water to these buildings through insulated underground lines, is also in this room. A secondary circulator is located in each building to tap the primary circuit and pump water to the heating elements. The primary circulator operates continuously until the outdoor control thermostat shuts it off at 65°F.

Each building has its own automatic control system regulating the temperature by on-off operation of the circulator or blower motor.

The change house is constructed of uninsulated fabricated steel subdivided by partitions 9 ft high. The building is heated by four floor-mounted unit heaters with nozzles to distribute the warm air overhead.

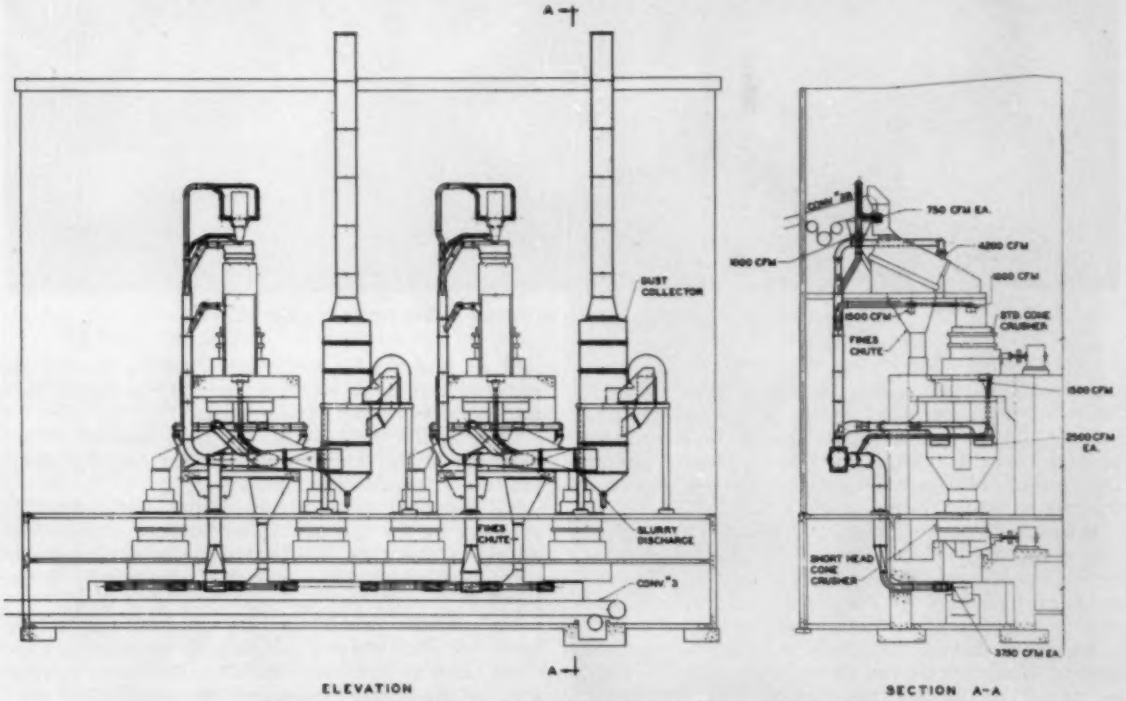
The other three buildings are heated by enclosed finned-tube direct radiation, with one exception—the laboratory in the safety and ventilation office must be dust-free and pressurized and is heated and ventilated by a unit placed on the roof. This unit contains Cambridge high-efficiency air filters and a hot-water heating coil that maintains 70°F during the heating season by means of thermostatically controlled face and bypass dampers.

Plantsite: Only such areas as offices, change rooms, lunch rooms, and toilet and shower rooms are heated at the plantsite. These areas are small and widely scattered. Those in the shops have no windows or openings to the outside.

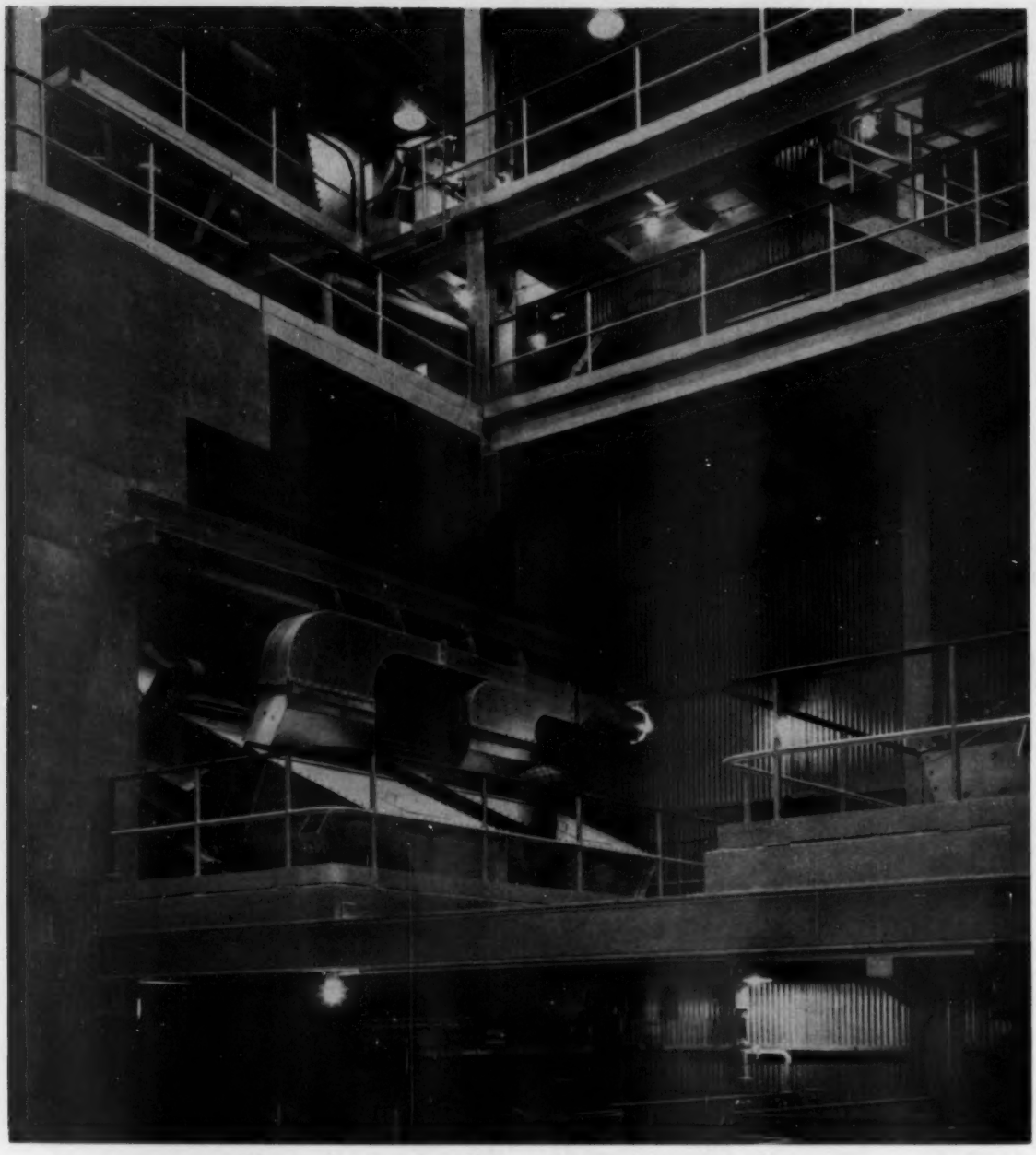
To provide make-up for spaces in which exhaust was necessary and to provide warm weather ventilation it was decided to employ air-handling systems that would introduce 100 pct outside air into each space. The temperature of the incoming air is automatically maintained sufficiently higher than room temperature to balance the heat losses. Air quantities were fixed to provide adequate warm-weather air change while maintaining satisfactory cool-weather heating conditions. In some cases two-speed motors were used to furnish higher air-change rates during hot weather.

All toilet rooms, shower rooms, and change rooms have mechanical exhaust systems that discharge outside the building.

Automatically controlled heating and ventilating units with viscous washable filters and hot-water heating coils are used for each system. Heat sources



Elevation of secondary crushing plant showing dust control units.



Effective dust control installation in the secondary crushing plant.

for the heating systems and domestic hot water are cast-iron oil-fired boilers for loads under 500,000 Btu's and package boilers for the higher capacities.

Hard-drawn type *L* copper tubing, with wrought or cast sweat fittings, is used for all water piping. Ductwork is fabricated of galvanized sheet steel according to ASHVE standards.

Industrial Ventilation: Air is circulated in the general shops and railroad repair buildings by continuous clamshell gravity-type roof ventilators. The ore-handling buildings are not completely enclosed and require no general ventilation systems.

Electrical installations such as large-horsepower motors, electrical control rooms, tunnels, and lubricating-oil rooms are pressurized and ventilated. Since the climate is dry it was decided to use capillary air washers for evaporative cooling and at the same time to filter and add humidity to the air required for ventilating these spaces.

Cooling the air reduces the total amount of air needed and the addition of moisture helps prolong the life of the electrical insulation.

All electrical spaces are maintained under positive pressure by the use of counterbalanced dampers in all relief openings. No heat controls or automatic controls are provided—when the temperature drops to 40°F, the systems are manually shut down.

No unusual problems were encountered in the design of dust control, heating, or ventilating systems, since most of the difficulties had been eliminated by the initial design and by unitizing the systems.

POWER SYSTEM

by **STANLEY F. FRENCH**
Chief Electrical Engineer
Anaconda-Jurden Associates Inc.

Power for El Salvador operations is obtained from the existing Barquito-Potrerillos system. Main source of supply is the 30,000-kv plant built in 1926 at Barquito, near the port of Chañaral. This plant has four three-phase, 60-cycle turbo-generators, each rated at 7500 kw, 6600 v, stepped up to 88 kv for transmission to the original Andes Copper Mining Co. reduction works and mine at Potrerillos some 80 miles away. The power line consists of two circuits, each composed of three 115,000-cir mill copper conductors. Power for the new operations was taken from this original transmission line at the nearest accessible point and from the new switching station installed at Llanta. The new line terminates in the main substation at El Salvador, a distance of 13 miles. This is a two-circuit steel-tower transmission line of the same general characteristics as the original.

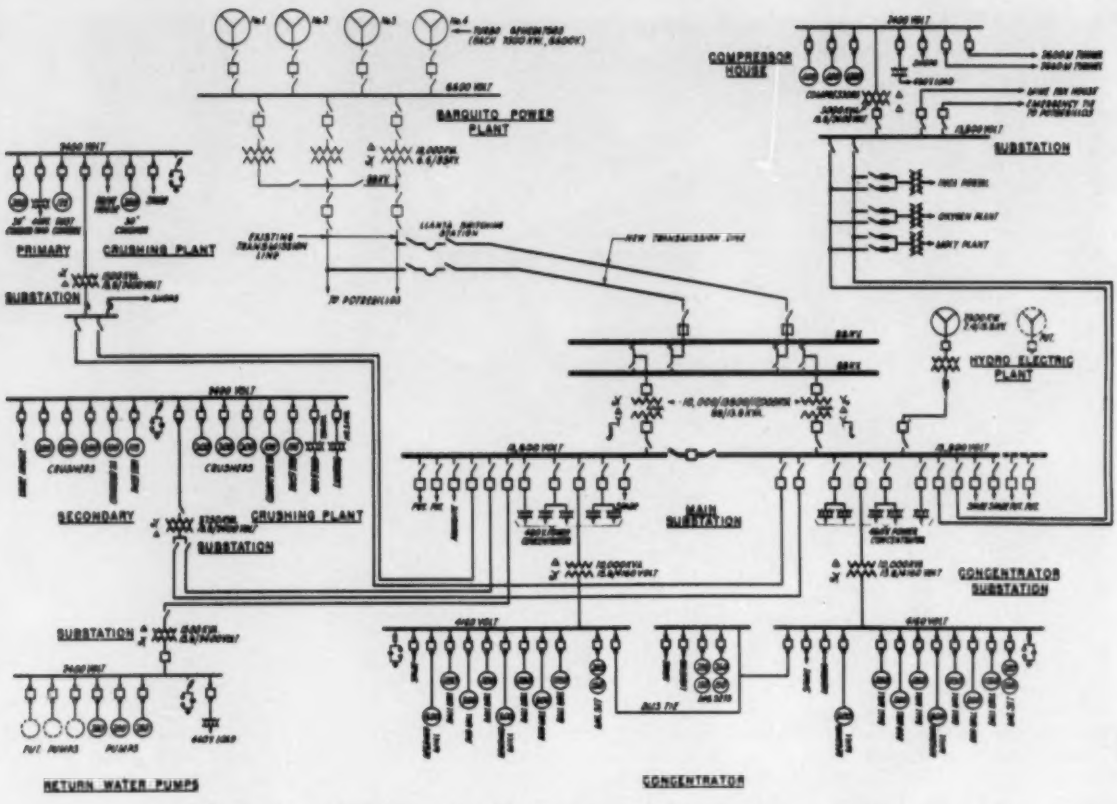
The switching station at Llanta is somewhat unusual in that circuit interruptors of 115-kv, 600-amp, 600-mva capacity provide fault protection for El Salvador branch, this being the most economical way of furnishing the necessary interrupting capacity and relaying facilities. There were no particular problems with the transmission line itself except for negotiating the steep slope leading up the side of the ravine above Llanta. By taking advantage of natural contours, it was possible to avoid using special towers and footings; in the most difficult locations, clearances were obtained with standard towers and standard extensions.

Power Distribution: As noted in the diagram (page 374D), the main substation at El Salvador consists of a double-bus, high-tension structure feeding through selector switches to two transformers, cooled by forced air, each rated at 10,000/13600/17,000 kva. These step down the voltage to supply the main distribution power at 13,800 v to a sectionalized bus. In the event of failure of either transformer, 70 to 75 pct of production can be maintained by the maximum forced air rating of the remaining transformer.

Both the high-tension and 13.8-kv busses are combined in one structure, with all outdoor feeder breakers rated at 600 amp, 250 mvs IRC. These breakers are solenoid (rectifier) closing 230 v a-c, with 125-v, d-c trip. Cables in underground tunnels distribute power from the main substation to the concentrator substation, which consists of two 10,000-kva, three-phase, 13,800/4160-v transformers. Other areas are supplied through underground cables to a terminal structure from which overhead circuits are carried to the mine, primary and secondary crushing plants, pumping stations, etc.

An auxiliary source that can also supply limited power in case of emergency is the small hydroelectric plant located near the reduction works at the terminus of the main pipeline supplying water for the process and townsite. The Pelton wheel driving the generator operates at about 2100 ft head of water and is rated at 2500 kw. In normal operation plant requirements are approximately 19 cfs, 16 of which pass through the Pelton wheel; the remainder is

Main power substation at El Salvador.



Schematic drawing of power distribution—one line diagram of main connections.

diverted to the plant reservoir. Discharge from the Pelton wheel also is carried into the reservoir.

The power thus obtained continuously is derived from the excess head of water required mainly in the reduction processes. Power for the townsite, which will ultimately house a population of 7500, is carried from the main substation at 13,800 v, and primary distribution is made throughout the townsite at this voltage. House service providing power for ranges, heating, and lighting is furnished by banked secondary transformers. The combined distribution and transformer capacity provides for a demand of 2.15 kw per service for domestic areas, which compares very favorably with the densest completely-electrified residential areas in the U. S.

For mine distribution, power at 2400 v goes overhead from the mine substation to the vicinity of each of the three tunnel entrances and thence to all of the underground unit substations by rubber-insulated neoprene-jacketed cables. For tramming purposes power is converted in underground rectifier stations to 250 v d-c for the 2600 and 2660-meter levels and to 550 v d-c for the main ore haulage tracks emanating from the Inca portal. On the latter level, ore trains are hauled by 45-ton electric locomotives and dumped at the primary crushing plant.

In the concentrator proper, where the greatest amount is utilized, power is distributed to the large motor circuits at 4160 v and carried from the basement of the concentrator control room by rubber-insulated neoprene-jacketed cables direct to the individual motor foundations. Largest users of power in the concentrator are the 800-hp rod-mill motors and the 1250-hp ball-mill motors, both of which must be started on full voltage to deliver the 175 to 200 pct torque required to start a fully loaded mill. The resulting in-rush current is 650 to 700 pct of normal. For these reasons care must be exercised in the design of the feeder and bus system to provide for adequate carrying capacity under starting conditions. When calculations for voltage drop are made, consideration must be given to the system reactance so that under the worst starting conditions there will be enough voltage to provide the required starting torque. Power is supplied to each of the large units through circuit breakers enclosed in metal-clad switchgear cubicles of rugged construction in order to insure low maintenance under severe service and, at times, frequent starting. All circuit breakers connected directly to main busses are designed to have enough rupturing capacity to handle the short-circuit current of the system. All enclosed bus compartments in important switchgear are provided with piped CO_2 for automatic fire protection.

The 440-v power for the flotation section is furnished from six 1200-kva unit substations and two 750-kva unit substations. An innovation in the 440-v supply was the location of the unit substations and motor control centers in waterproofed structures or control rooms under the flotation floor. Each control room so located is supplied with clean and cool air through an overhead duct in order to reduce the problem of maintenance in these and similar areas where alternate dust and moisture constitute a hazard and maintenance problem. All secondary distribution from these control rooms

is made in open cable trays, except that where runs to individual motors leave the trays, suspension on open insulators is employed. Rubber-insulated neoprene-jacketed multiconductor cables are used throughout the length of all runs in this wet area.

Color-Corrected Lighting: Since it is desirable to observe the flotation system under color correction, the lighting system in the concentrator building will be described briefly. The system was designed for a maintained level of 40 ft-c in the flotation and regrind section and 25 ft-c in the grinding section. This was achieved economically with color-corrected mercury vapor lighting. Because of the different mounting heights across the building it was necessary to vary the beam spread and wattage of the overhead fixtures to achieve uniform distribution. The overhead fixtures and their associated ballast are serviced from the cranes. They are mounted with safe change hangers so that the fixture or the ballast may be taken down easily for maintenance. Industrial fluorescent fixtures are used extensively in all electrical equipment rooms. The outside building lighting system is controlled with a light-sensitive cell in conjunction with relays near the fixtures. In this way all lighting is controlled from one point with no voltage drop problems.

Standard towers on slope above Llanta.

PROCESS WATER AND HYDROELECTRIC PLANT

by **RALPH CONSTANTINI**
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Although El Salvador is in one of the world's most arid regions, its process water supply position is favorable. The Cordillera, about 36 miles to the east, includes some of the highest peaks in the Andes, which get a few inches of precipitation yearly as snow. Most of the runoff flows underground, reappearing as springs at lower elevations and forming a few small surface streams in the high tableland.

The largest stream is the Ola River at 11,650 ft. The engineers who planned the Potrerillos operation more than 30 years ago built a small dam across this river and laid a pipeline approximately 34 miles long to carry the entire flow to Potrerillos for process uses.

Because the Ola water sources are entirely of ground flow origin the available flow is essentially stable all year round at about 26 cfs, and the dam is small since it is required to provide very little pondage. For the same reasons the water is quite high in dissolved salts and therefore unsuitable for drinking or agricultural purposes.

In view of the corrosive character of the water it is not surprising that after more than 30 years of operation the old pipeline to Potrerillos has deteriorated badly, mostly at its riveted seams. In addition to needing constant repair it can now deliver only about 22 cfs of the total flow available at the Ola dam. However, even with this reduced flow, of which about 2 cfs will still be required at the Potrerillos smelter and 1 cfs at the plant and new townsite, the remaining 19 cfs (52,000 tpd) available for ore processing at the new 24,000-tpd El Salvador concentrator is considered adequate.

To bring this water to the plant there are 18.4 miles of new pipeline branching off from the old line at the tail race of Montandon hydroelectric plant. The new installation includes 23 miles of old line at the head end of the system. The remaining 11.2 miles of the old line to Potrerillos will also continue in service.

Because of the rugged terrain traversed and the high heads available, it was originally found economical to install two small hydroelectric plants along the route of the old line, one a 1000-ft head,

2000-kw plant at Montandon which utilizes all of the pipeline flow, and the other a 2100-ft head, 2200-kw plant connected on a bypass from the main line at Sifon Bajo to utilize about half the total flow not required for process at Potrerillos. When the new El Salvador branch pipeline was designed, it was deemed economical to install a new hydroelectric plant at the end of the line, especially since the operating head at that point could be made the same as that at the Sifon Bajo plant. In that way it was possible to re-install the old Sifon Bajo turbine and equipment at the new site; otherwise it would eventually have been scrapped.

The new branch line runs transversely to the prevailing drainage topography over extremely rugged terrain; its profile has a continuous *roller coaster* pattern. Over much of the route there are high pressures and heavy anchoring.

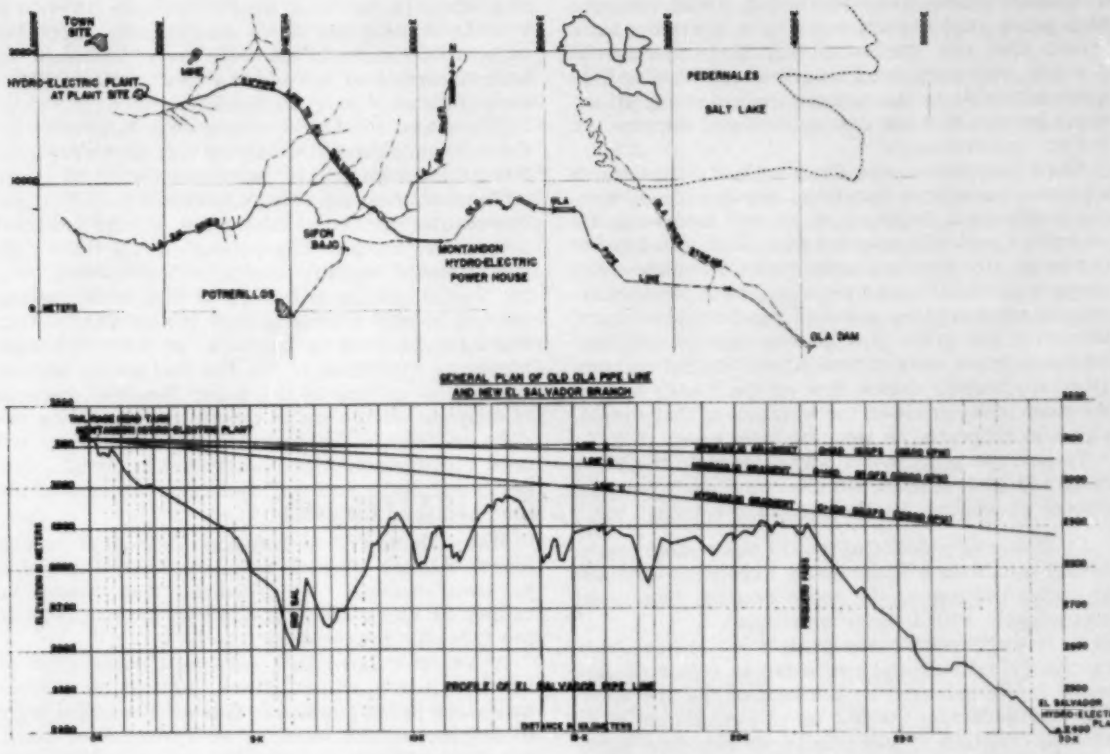
Size of Pipeline: The size of the new line was determined, for most of the way, on the basis of its retaining a capacity of at least 28 cfs (75,000 tpd) even if its Hazen-Williams factor should ever deteriorate to a $C = 100$ condition. This would provide for possible expansion of El Salvador concentrator in the future.

The available hydraulic gradient between the tail race tank at Montandon, at elevation 10,243 ft, and Pisquero Pass, 13.8 miles downstream at elevation 9519 ft, is exactly 1 pct. With this gradient a 26-in. OD pipeline with a ½-in. average wall thickness, which was considered first, would have a capacity of only 24 cfs (65,000 tpd) at $C = 100$. A 28-in. pipeline, on the other hand, would have a capacity of 30 cfs (81,000 tpd) under the same condition. Hence the 28-in. OD size was considered necessary for the first 13.8 miles. For the remaining 4.7 miles beyond Pisquero, a gradient of about 7 pct is available. If it had been intended only for the purpose of conveying the future maximum amount of water to the plant, this portion of the line could have been reduced to 18-in. size. However, a study showed that if the 28-in. size were retained all the way to conserve head it would make possible an initial 2200-kw hydroelectric installation at El Salvador, and ultimately a 3800-kw installation when the maximum amount of water would be made available. The increased cost for pipeline and hydroelectric plant, if the old Sifon Bajo turbine and equipment were utilized, was estimated at about $500,000, or slightly more than $200 per kilowatt, which was considered exceptionally worth while in an area of very high fuel costs. Therefore the 28-in. OD pipe size was used all the way to the plant.

Pipeline Material and Wall Thicknesses: The pipeline will be subjected to operating heads as high as 2165 ft (950 psi). To withstand these heads electric fusion-welded pipes were utilized, in wall thicknesses varying from ¼ in. to ⅝ in. and made from both low-carbon steel (ASTM A-283 grade C) and low-alloy high-tensile steel (ASTM A-242).

Originally it was planned to use only low-carbon steel pipe, which would have required thicknesses

Twenty-eight-inch process water pipeline crossing Rio Sal.



of ¾ in., ⅞ in., and 1 in. for about 19,000 ft of the line. However, the Chilean Cia. De Acero Del Pacifico, which supplied the pipe, was not equipped to manufacture it in thicknesses greater than ⅝ in., and to obtain this pipe from the U.S. would have involved an impossible delay because of the prevailing scarcity of steel pipe at the time. Therefore the practicality of a high-tensile steel material that would not involve thicknesses greater than ⅝ in. was investigated.

It was found that by using a low-alloy, high-tensile steel made in Chile, having a 50,000-psi minimum yield strength as compared to 30,000 psi for the low-carbon steel, it would be possible to substitute 7/16-in., ½-in., and ⅝-in. high-tensile steel for the ¾-in., ⅞-in., and 1-in. low-carbon steel. This solved the availability problem, and the high-tensile pipe cost 15 pct less per foot than low-carbon pipe of equivalent strength.

The design pressure at any point was determined on the basis of the expected hydraulic gradient, with the minimum initial flow of 19 cfs and an expected initial Hazen-Williams friction factor of $C = 140$. Wall thicknesses were then proportioned on the basis of working stresses of 50 pct of the yield strength of the material. This resulted in working stresses of 15,000 psi and 25,000 psi, respectively, for the low-carbon and high-tensile steels. These are higher than normally used, since the AWA recommends working stresses of 12,500 psi for low-carbon steel pipe. It was believed, however, that this stress is unduly conservative for pipe manufactured under modern methods of quality control and used in lines continuously supported along the ground, as in this case. The 20 pct higher working stresses were used, therefore, and resulted in a considerable saving in pipe steel tonnage.

Stresses some 10 to 20 pct higher than the above, depending on location along the line, might be developed for short periods if the line were subjected to the full hydrostatic head or to the overpressures caused by water hammer. However, because the output and speed of the turbine at the end of the line are not governor-controlled and also because a by-pass valve has to be opened simultaneously to maintain the flow of process water to the plants when the turbine is shut down, the line will seldom be subjected to the full static head or to overpressures. For those brief occasions when the stresses will still be no larger than 60 pct of the yield strength, it was considered permissible to allow slightly greater stresses in the same manner that 33 pct greater stresses due to wind loads are generally allowed for in building design.

Pipeline Coating: The water to be carried is brackish, and so it was considered important that the interior of the pipeline be protected against corrosion; otherwise there would have to be an extra thickness of at least ⅛ in. No corrosion protection for the exterior of the line was considered necessary, because the terrain traversed is extremely arid and the soil totally devoid of moisture for most of the way. For these reasons it was decided to treat the interior of the line with a spun coaltar enamel coating 3/32 in. thick, applied hot in accordance with AWA specification C-203. The exterior was given a coat of aluminum paint primarily to protect the interior enamel from damage due to high temperatures caused by exposure to intense desert sunlight before installation. The coating is expected to protect the pipeline against corrosion indefinitely. An additional benefit of the coating is that the smooth glass-like finish has a low friction factor.

It was hoped that the completed line would have

a Hazen-Williams factor of $C = 140$. Actual pressure data taken after the line was put in operation have shown that this factor initially is very close to $C = 150$, and more head than was expected is thus made available to the hydroelectric turbine. Hence it can be seen that the interior lining of the pipeline is very worth while.

Field Installation and Couplings: It was decided wherever possible to install the line in a trench having a minimum depth of 18 in. and to mound the excavated material over the pipe. This was done to minimize any pipeline motion due to temperature changes and earthquake tremors. The depth was increased whenever the pressure was 500 psi or more, whenever the grade was greater than 10 pct, and wherever there were curves. At the Rio Sal crossing (the only visible stream flow on the route) and on the steep rocky grade on the west side of that stream, pipe was supported on concrete piers every 15 ft.

To join the pipe, which was shipped to the plant mostly in 30-ft lengths, Dresser couplings were used instead of welding for the following reasons:

1) It was very doubtful that in this remote region enough qualified welders could have been obtained to install the line at the speed desired. This speed was possible with Dresser couplings.

2) If welding had been used, it would have been extremely difficult and expensive to repair the interior lining damaged by the heat of the operation.

3) By deflecting the line up to a maximum of 4° at each coupling, it was possible to negotiate many changes in direction both in plan and elevation through gradual curves. In this way the contour of the rolling ground profile could be followed very closely and excavation and welding could be held to a minimum. The alternative with welding would have involved much cutting and scarfing of pipe. Because of the high pressures generally prevailing, the deflection per joint had to be limited to much less than the 4° permitted by the coupling. Deflections were generally determined on the basis of limiting the disruptive outward force developed at the joint owing to change in direction to one half the reaction due to weight of pipe and content effective at the joint.

Despite the use of many horizontal and vertical curves, the rugged terrain necessitated a number of sharp changes in direction, and heavy anchors of the gravity type were needed to resist the large hydrostatic disruptive forces involved. Some of these anchors required as much as 120 cu yd of lean concrete, and it is estimated that the cost of anchoring represents about 5 pct of the total cost of the line. Total cost of the couplings, their installation, and the anchoring is estimated at 15 pct of the total cost of the line. The alternative in this case would have been even more expensive.

Venting and Draining: There are manually operated valves at all high and low points of the line to permit venting and draining during repairs. A multitude of automatic vacuum-release valves at all the high points was regarded as unnecessary. Because the minimum ¼-in. wall thickness used results in a theoretical collapsing pressure of 35 psi for the 28-in. pipe, the line was considered safe against this hazard in the event that vacuum develops at the high points for any reason. With the prevailing atmospheric pressure of 10 psi at the high points, therefore, there is a safety factor of 3.5 against collapse which was considered adequate for a continuously supported pipe. This judgment has been fully confirmed by tests on completed line where a vacuum was deliberately induced at many high points without difficulty.

It was also considered unnecessary to provide for the automatic release of any air that might accumulate at the high points, as recommended by many authorities, because it was believed that this accumulation would not take place. It was reasoned that, since the operating pressure at all these high points would amount to several atmospheres, any air that might be entrained at the intake would amount to only a small part of the air volume that could be dissolved by the water at these increased pressures. Operation of the line has amply demonstrated the validity of this point. However, because of frequent shutdowns of the entire line during repairs on the old Ola line above Montandon, it has been subsequently found convenient to install a few automatic air intakes and vent valves at some of the high points on the profile.

Water-Hammer Overpressures: Because of its long length the new pipeline was considered vulnerable to water-hammer overpressures that would be caused by quick shutting down of its discharge at the Salvador hydroelectric plant.

It was calculated that for any closure time of less than 1 min, which is time required for a pressure wave in the pipeline to travel from El Salvador to Montandon and back, an overpressure of about 300 psi would be generated. Since this would subject the portions of the line with the ¼-in. wall thicknesses to about 2½ times the design pressures, a slow rate of operation is imperative on both the turbine nozzle valve and the bypass valve at the Salvador hydroelectric plant. Estimates indicate that these overpressures can be reduced to about 5 pct of the maximum if the time of valve closure is not less than 10 min. Manual controls on the old turbine nozzles and the new bypass valve have been equipped with an extra gear train to insure this slow operation.

Hydroelectric Plant: The initial turbine generator unit and transforming equipment in the new hydroelectric plant at the end of the 28-in. line at El Salvador was formerly installed at Sifon Bajo on the old Ola line. After 22 years of operation in that location it was still in good operating condition. This appears to bear out the usual contention that hydroelectric plants depreciate at a much slower rate than steam plants.

The turbine has a single overhung Pelton wheel of 43.5-in. pitch diameter mounted on the generator shaft. It runs at 900-rpm, 60-cycle synchronous speed and is rated at 2900 hp at a capacity of 14 cfs and 2150 foot-head and with 85-pct hydraulic efficiency. The nozzle can, however, handle a maximum of 16 cfs of the 19 cfs initially available to generate a proportionate increase in power. Since only the power potential of the 3 cfs that must be bypassed to the plant reservoir is wasted, a second turbine unit would not be economical at present.

Possibly in the future, when up to 28 cfs may be made available to the plant by renewal of the old Ola line to Montandon, it will be practical to install a second turbine unit with a 14-cfs rating identical to the first. The foundation and superstructure of the new plant allow for installation of a future unit.

A flow of 28 cfs in the pipeline will cause the hydraulic gradient at the power plant to drop to 1940 ft with a friction factor of $C=140$; consequently there would be a drop in power per unit. However, total power capacity of the future plant would still amount to some 3800 kw, an economical installation for the investment involved.

Since generator output is only about 10 pct of the power in the 13-kv system, its speed is synchronized with the frequency of the system, and no governor control of the nozzle valve is needed. This eliminates the major cause of water-hammer overpressures in penstocks.

The turbine does have a deflector type of governor that intercepts and diverts the nozzle jet to prevent damage to the turbine due to runaway speeds, but this comes into play only if the breakers trip, causing the generator to lose its load.

The water flows from the tailrace of the turbine to the plant reservoir tanks close by, and from these it becomes available to the plant for process purposes.

When the turbine is shut down or when the water exceeds turbine capacity, a slow, manually operated angle-needle valve, similar to the turbine nozzle, discharges the water vertically downward into an energy-absorbing pit where the jet is turned 180° on itself. The capacity of this valve will permit bypassing the maximum future pipeline flow to the plant reservoir.

POTABLE WATER SUPPLY

by JOHN P. MANNING
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Responsibility for developing a potable water supply that could furnish about 700 gpm was assumed by the Potrerillos operating staff. The staff took charge of the gathering lines bringing water to the deaeration plant at Asientos Springs and the system of pipelines carrying it from this plant to El Salvador.

The two lines to El Salvador diverge at Pisquero Pass. One circles the north and east sides of Indio Muerto Mt. to supply the mine plant area and continues to the reservoir for the townsite. The other line skirts the west and south slopes to bring a supply to the plant reservoir before going on to its termination, also at the town reservoir.

Gathering Network: This 52-mile network is made up of steel pipelines, mechanically coupled, ranging in size from 2½ to 10 in. All pipe used for potable water to the project was produced in Chile by Cia. de Acero del Pacifico at its Huachipata mill.

Most distant source of potable water is the Cerro Nevado (Corrales) area, where there are three springs. The spring at Rio Negro, elevation 13,950 ft, is also the highest source. This compares with an elevation of 10,175 ft at the Asientos deaeration plant and 7610 ft at the townsite reservoirs. The pipeline from Cerro Nevado to Asientos is nearly 37 miles.

The output from several groups of springs at Pastos Largos, another principal production area, is collected in a pipeline that joins the one from Cerro Nevado to Asientos. This system constitutes the high-pressure supply to the hydro-vacuum jet pumps used to deaerate water.

The two other localities where water springs were developed, Asientos Springs, just above the deaeration plant, and Calorados, are both at lower elevations. Gathering lines from each source run separately to the deaeration plant. Least desirable as to chemical properties is the Asientos Springs water. This supply is segregated, to be used or discarded as dictated by demand.

The total quantity of potable water developed, subject to some annual and seasonal variations, is on the order of one million gallons per day when the water from Asientos Springs is excluded, or is increased by 170,000 gpd when that is included.

Deaeration Plant: This plant, designed by Anaconda-Jurden, is in an isolated area at 10,175 ft. Its function is to remove dissolved and entrained oxygen from the water coming from various sources before it is fed into the pipelines leading to El Salvador.

There are 62 miles of 4 to 10-in. steel pipe in the two lines from the deaeration plant at Asientos Springs to El Salvador. Since high pressure water power was available to operate the hydro-vacuum jet pumps, it was more economical to deaerate the water than to line so many miles of pipe with coaltar enamel. Deaeration will also protect an existing long-branch connection to one El Salvador line carrying water to Barquito, where the company's steam power plant is located.

A visible-flow gas chlorinizer of the volumetric, solution-feed, vacuum type was installed to insure purity of the drinking water supply. Periodic manual adjustment of its setting will correlate its constant rate of feeding to any variations in the amount of water going through the plant. The inspector can check this by reading a meter installed in the plant's outgoing line.

The deaeration plant itself comprises three identical sections—two operating units and a standby. Each unit consists of a 10-in. special hydro-vacuum pump working in conjunction with a wood-filled steel deaerating tower 6 ft in diam by 22 ft in overall height. The high-pressure water connected to each pump maintains an absolute pressure of 0.7 in. hg in the suction that is connected to the top of the tower.

Water comes into the deaerating plant through three pipelines. The high-pressure water from Cerro Nevado—Pastos Largos is piped directly to a common inlet header for the three pumps, whereas the pipes from Asientos and Caloradas terminate in separate sumps.

Discharge from the pumps flows through pipes acting as barometric legs, which discharge into the same sump receiving water coming from the Caloradas area.

Both sumps are connected by overflow spillways to a larger and deeper sump, from which all towers receive their feed, each through an 8-in. pipe leading to a distributor near the top of the tower. When the water has trickled down through the packing it collects in the bottom of the tower and is discharged through an 8-in. draw-off connection leading to a 10-in. gravity-plant discharge line common to all units.

Rate of deaeration is controlled for each tower by a float resting in the pool of deaerated water. Through a direct linkage the float controls the position of the butterfly valve vane in the raw-water feed line, opening or closing the valve as the level of the pool falls or rises.

The less desirable water from Asientos Springs is high in calcium and sulfates as compared with that from the other sources. This supply comes into a separate sump and is directed out again to waste through an overflow whenever the level in the raw-water sump, owing to lack of demand, is above the invert of the plant overflow located in this compartment.

Each unit is designed to remove 6 lb of air per hr when the pumps are supplied 50°F water at the rate of 400 gpm at 800 psig. The absolute pressure maintained under those conditions is 0.7 in. hg. Performance under estimated minimum conditions at the same pressure is 4.2 lb of air removed with water at the same temperature but at a rate and pressure of 280 gpm and 400 psig respectively.

The Deaerated Water Pipelines: The 10-in. line leaving the deaerating plant extends for about 1.3 miles toward El Salvador, where it forks into two 8-in. lines. One of these goes to the townsite reservoir along a route that skirts the metallurgical plant, where the flow of a branch terminating at a reservoir is controlled by a float valve. The flow of the other line, which runs around the north side of India Muerto, is interrupted at the mine area. There an orifice controls a free discharge into an open tank. Demand at this point is less than the supply to the reservoir, resulting in a constant overflow which then enters another enamel-lined pipeline that carries it to one of two ½-million gallon reservoir tanks at the townsite. Any water in excess of the combined requirements of the project is allowed to overflow from the town's reservoirs.

No valves have been installed in the lines between the deaeration plant at Asientos and El Salvador because it was believed that improper operation could cause water-hammer effects. Long experience in this area has impressed on the operating staff the wisdom of limiting controls to orifices that require no maintenance and can not be tampered with by unauthorized personnel.

Airborne camera takes a look at El Salvador's "oasis town" in the course of development. Majority of the houses shown are now occupied

TOWNSITE, HOUSING, TRANSPORTATION, AND WELFARE

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El Salvador's three centers of activity—the mine at Indio Muerto, milling operations at the Inca portal, and the townsite itself—are at the corners of a triangle, connected by paved roads five to six miles long. Employes commute by scheduled bus service between these focal points.

At Potrerillos, former center of Andes operations, are the business offices, smelter, and hospital. Public buses operate over the 25 miles of road between El Salvador and Potrerillos, and the railroad from Potrerillos to the port of Chañaral, about 90 miles away, connects with north and south lines of the Chilean National Railway at Pueblo Hundido.

Below Potrerillos, along the railroad, is the company town of Llanta, where railroad yards and a supply depot are situated. Llanta receives all goods shipped as rail or ocean freight and routes them to Potrerillos by railroad or to El Salvador by truck on a paved highway. El Salvador residents go to Llanta by car to pick up the track car for the coast.

Chief supply route for the company is by ship to Chañaral, which is served by airline, train, bus, and ocean steamer. The main power plant and receiving facilities for transhipment of incoming supplies and outgoing blister copper are at Barquito, the company community adjoining Chañaral. Here too are the hotel and guest houses, schools, hospital, and theater. Vacationers from Potrerillos and El Salvador find relaxation at Barquito—swimming, deep sea fishing, golf and tennis. There is fly fishing and duck hunting along the Ola River in the Cordillera.

A new paved airport between El Salvador and Potrerillos is serviced by scheduled airline, bringing the northern city of Antofagasta only 1½ hr flight time away. A 2½-hr flight due south above the northern Atacama desert reaches the central agricultural part of Chile, where the capital city of Santiago lies in a fertile central valley at the foot of the Andean range.

General plan of El Salvador townsite. 1) Company store and bakery. 2) theater, 3) stores, 4) stores and offices, 5) church, 6) hospital, 7) dormitories, 8) Chilean school, 9) nine playgrounds, 10) workers' clubs, 11) technical school, 12) stadium, 13) cemetery, 14) police headquarters, 15) bus garage, 16) service station, 17) staff area school, 18) staff clubhouse, 19) golf course, 20) fire station, 21) welfare offices.

THE TOWNSITE

The aim of architectural planning at El Salvador was to develop an attractive, modern town that would be a highly desirable place to work and live. The final plan, selected from a number of layouts, completely avoids the "industrial look."

The overall plan was evolved by coordinating three principal zones with the traffic pattern. These groupings are:

1) Five hundred and seventy-six duplex houses for employes, comprising eight designs, on streets radiating from a plaza 300 ft square.

2) Forty one-story staff houses comprising four designs.

3) Plaza and public buildings.

Traffic for years to come will be chiefly pedestrian; buses are practically the only vehicular transportation, and supplies to stores and hospitals are delivered by arteries so arranged that trucks will not enter the town itself.

Streets are either 30 or 50 ft wide and lead to the plaza or are concentric to it. Street blocks for the employes' houses are generally 350 ft long by 132 ft wide, and the width of the block is divided by a 16-ft service alley. There is incandescent lighting on all streets except at the plaza, where there are mercury vapor lights mounted on decorative poles.

Bordering on the plaza, which has a bandstand and circular promenade, there is a church, a 600-seat theater, a large company store and bakery building, and other commercial establishments such as a bank, post office, telephone and telegraph offices, hotel, and private stores. Each public building has a heating plant suitable for its individual needs, and each house has its own central heating system.

Police headquarters are located strategically at the town's entrance. A large medical center, convenient to the housing zones, is also accessible to the main artery leading to the mine and plantsite. Smaller buildings—fire house, bus garage, auto service station, and employment and welfare building—are placed within or near the townsite to suit their particular function. Other facilities, such as a sewage-treatment plant, single-runway airfield, livestock corral, and slaughterhouse, are located away from the town proper.

Educational Facilities: In the center of the principal housing area there is a company-supported school, operated under the Chilean education system, for Spanish-speaking children. The school building is complete with auditorium and library and large enough to accommodate 1000 children in the 6-to-14 age group. For English-speaking children there is a small separate school with the usual first eight grades, patterned after the New York State school program.

Spanish classes on a voluntary basis are provided for foreign residents. All these educational services are free of charge.

Building Design and Construction: All building construction is fireproof and designed for the earthquake condition that prevails throughout the area. All designs meet or exceed code requirements of

local and national agencies having jurisdiction. Most technical drawings were prepared in both English and Spanish for construction and municipal convenience.

Building designs and color schemes are varied, roads within the housing areas are curved, and there are spacious parks and playgrounds. The two-tone pastel of the employes' housing is adopted in ten different color combinations and diversified throughout the area so that repetition is not discernible.

Local tradition dictated the use of walled enclosures for individual yards of the duplex houses. These walls are 6 ft high at the rear service yards and 4 ft high on the street sides. Since the natural topography slopes upward slightly from the plaza, some of these walls are stepped. Many of the houses have entrance steps at either the front or rear, depending on which direction the houses face. This varying effect also lends interest to the block groupings.

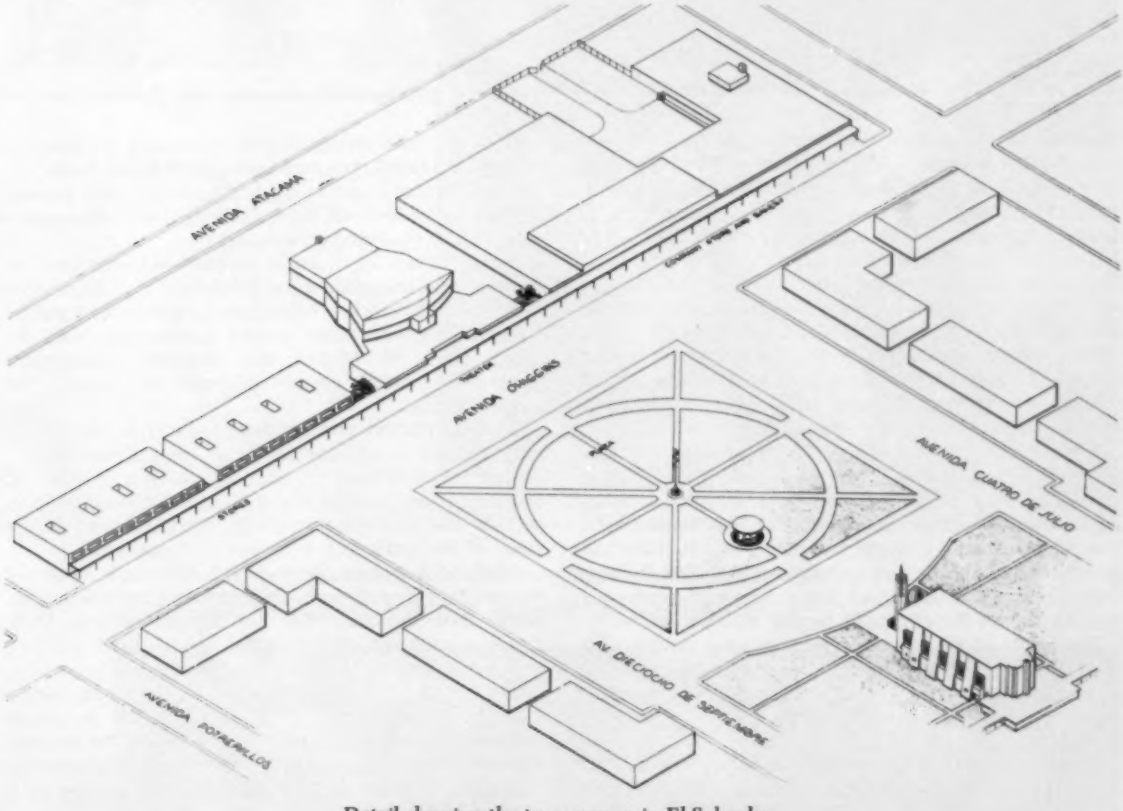
Employes live in two-family duplex houses, each unit consisting of a living-dining room, bedroom, and kitchen on the first floor and two or three bedrooms and a bathroom on the second floor. Exterior and interior walls are re-inforced concrete block with a paint finish. Windows are steel casements. Floor and stair are cast-in-place concrete, and the roof is constructed of precast concrete slabs. Floors on the first story are of lingue wood, except for the kitchen, which is floored with asphalt tile like the second-story rooms.

Each staff house comprises a living room, dining room, kitchen, utility room, three or four bedrooms, and two bathrooms, as well as a carport, service annex consisting of maid's room and bath, and a large storage room. The exterior is finished in stucco over re-inforced concrete blocks and the roof and interior partitions are of wood framing. The interior is finished in plaster over metal lath except in bathrooms, which have tile walls and floors. Floors in the foyer, living room, and dining room are of parquet wood blocks; others are asphalt tile. All closets have sliding wooden doors.

Completely modern systems of water supply, sewerage, and sewage treatment have been installed for the townsite. There is a dual water distribution system, each with separate reservoirs and gridwork of mains, to insure against shortage of drinking water. One system carries potable water and the other service water (slightly brackish) for hydrants, sprinkler systems, and flushing of toilet fixtures in all homes and buildings. Both systems are fed by gravity from steel reservoir tanks situated on the hillside adjacent to the stadium. The sewage plant is of the trickling filter type and provision is made for recirculation within the plant.

Welfare: Social welfare is the function of a department especially developed for the purpose. The nature of the service is personal and vital to the health and well-being of individual families and the community as a whole.

Maintenance of houses, community buildings, streets, and grounds is controlled by the welfare department. Requests by house occupants for electrical, plumbing, carpentry, or masonry repair or even special cleaning services such as floor waxing, window washing, or painting are taken care of by the department. However, occupants are also in-



Detail showing the town square in El Salvador.

View at the edge of the townsite, showing poles carrying primary and secondary distribution.

structed in the proper maintenance of their houses and every assistance is given them in keeping their dwellings safe, clean, and attractive. Streets, alleys, public grounds, and buildings are observed with care to be sure that they are kept clean and in the best condition. The welfare department is responsible for having all this work done through the proper agency to the satisfaction of community standards and especially that of individual residents.

The department also controls the assignment of houses. This function entails a public census record which is maintained and used by government, municipal, union, and company authorities.

Overseas employes may rent furniture and appliances from the welfare department, and new residents may borrow linens and kitchen articles until their baggage is received. The department sometimes stocks a supply of groceries to tide the family over the rush of getting settled. The housewife learns that many of her household problems can be solved by applying to the welfare office.

Residents of El Salvador receive rent, water, and trash disposal free of charge, but fuel for heating or cooking must be purchased. The welfare department maintains necessary stocks of fuel in the homes.

Community recreation and entertainment also come under the welfare organization. On a routine basis all athletic fields are watered and maintained, and in addition team play is scheduled. Football is a popular sport—on Sundays the football fields are occupied from dawn to dusk. The temporary cinema is run on weekends, and facilities for community parties are provided on request.

Proper running of guest accommodations and reception and hospitality for visitors is a daily routine operation. Visitors are frequently prominent public figures in government or the professions, and for these and all others the welfare department attempts to satisfy special interests courteously and expeditiously.

Transportation within the property is regulated. Concessions to operate bus lines or taxi service are issued by Welfare. Arrangements are made for individual and family transportation in Welfare cars within the property and also in trackcars to the port of Barquito for business or vacations.

Medical Services: Apart from the work done by the welfare department, the company provides complete free medical care for employes and their families through the hospital, clinic, and visiting nurse service. Dental services are available locally.

To replace and consolidate present medical facilities at an early date, a 30-bed hospital is under construction. The building will become the nurses' residence when the hospital is finished. The medical services available will be on a par with those of a modern urban hospital in the U. S.

grinding at el salvador

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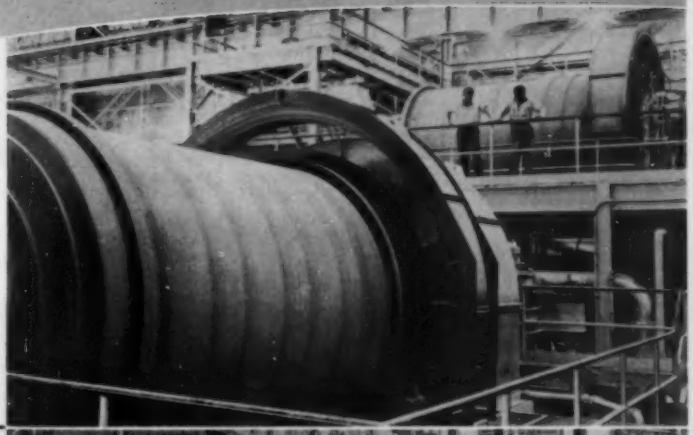

One of the eight 10′x 14′ Marcy Grate Discharge Ball Mills is shown in foreground, and one of the four 10′x 14′ Marcy Open End Rod Mills in the background.

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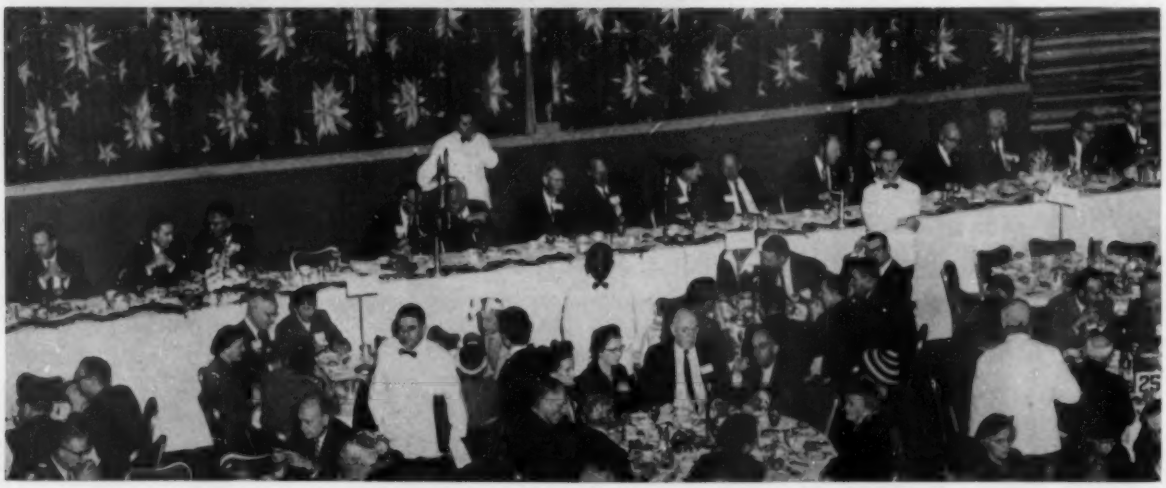
1960 ANNUAL MEETING, NEW YORK

Pictured at the Council of Economics luncheon on Tuesday are from left to right: Evan Just of Stanford University, speaker for the occasion; Douglas Donald, Behre Dolbear & Co., outgoing chairman; and Sheldon P. Wimpfen, Reynolds Mining Corp., 1960 chairman of the All-Institute Council of Economics.

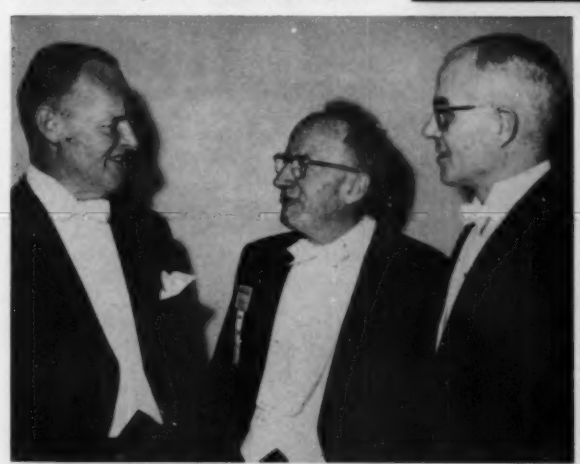
Dr. Joseph Gillson, incoming President of AIME, takes over the gavel from Howard C. Pyle, outgoing President, at the All-Institute business meeting held Tuesday afternoon in the Statler-Hilton grand ballroom after the All-AIME session.

The AIME Welcoming Luncheon was held Monday in the grand ballroom of the Statler-Hilton Hotel. Pictured below is the head table and part of the crowd in attendance. Far left: A. W. Schlechten, professor at the Missouri School of Mines and Metallurgy, accepts the award made to the Student Chapter for submitting the greatest number of Student Member applications during 1959. Pictured at the left is John W. Vanderwilt, president of the Colorado School of Mines, Golden, Colo. who was the luncheon speaker.



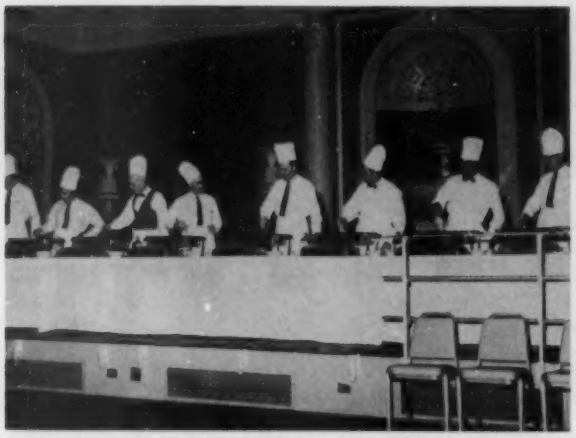
Pictured at the Council of Education panel on Sunday are: A. W. Knoerr, Stanley D. Michaelson, Ralph Rice, C. M. Brinckerhoff, Malcolm Wane (for J. D. Reilly), Chairman Stefan Boshkov.

During the convention, the Society of Economic Geologists celebrated the 100th birthday of the late Dr. Waldemar Lindgren. Among those associated with him, in their studies or in USGS work, pictured above right, were: Dr. Alan M. Bateman, Yale; Dr. L. C. Graton, Harvard; Herbert Hoover, former President of the United States, senior AIME Past-President; Scott Turner, New York, Director, Bureau of Mines, under Mr. Hoover, and a former AIME President; Dr. Joseph L. Gillson, Wilmington, Del., President of both SEG and AIME. Another event of special note was the luncheon on Thursday for AIME Past-Presidents. Among those attending, pictured at right, were: Back row, left to right: Carl E. Reistle, Jr., Humble Oil Refining Co.; Leo F. Reinartz, Armco Steel Corp.; Andrew B. Fletcher, St. Joseph Lead Co.; H. DeWitt Smith, consulting engineer; Howard C. Pyle, Monterey Oil Co. Front row: Clyde Williams, Scott Turner, Herbert Hoover, H. G. Moulton, and William M. Pierce.



AIME top officers for 1960 get together for a chat at the annual banquet. Left to right: Howard C. Pyle, Past-President; Joseph L. Gillson, President; and R. R. McNaughton, President-Elect. Mrs. Andrew E. Beer, president of WAAIME, pictured at the annual banquet in the company of Dr. Gillson, and Howard C. Pyle. Top AIME awards and honors were bestowed that evening.

1960 ANNUAL MEETING, NEW YORK



One of the most eagerly anticipated events of the Annual Meeting is the traditional MBD Scotch Breakfast. This year it was held Tuesday morning in the Terrace Ballroom of the Statler-Hilton. Pictured above left are a host of distinguished amateur chefs hard at work. From left to right: Wayne Dowdey, outgoing MBD chairman; Nathaniel Arbiter, SME treasurer for 1960 as well as an SME director; William B. Stephenson, SME director; Norman L. Weiss, SME director; Will Mitchell, Jr., Allis-Chalmers Manufacturing Co.; Donald W. Scott, SME Vice President; Edward H. Crabtree, director, Colorado School of Mines Research Foundation; and Raymond E. Byler, Western Machinery Co. Among those enjoying the proceedings were Mrs. J. L. Gillson; Dr. Joseph L. Gillson, AIME President for 1960; and standing, H. Rush Spedden, incoming chairman of MBD, shown in the picture to the right above.

Below: The Scotch Breakfast gets off to a start amid the flourish of bagpipes as the beginning of the procession forms.

Highlighting the Industrial Minerals luncheon on Tuesday was the presentation of the Hardinge Award to Samuel H. Dolbear. At the left, pictured at the head table are Mr. Dolbear; B. C. Heezeen, Lamont Geological Observatory, who was the luncheon speaker; J. G. Broughton, State geologist for New York and out-going chairman of the Division; and R. H. Feierabend, Freeport Sulphur Co., 1960 chairman. Pictured above left are: Mrs. S. H. Dolbear, wife of the award winner and active in WAAIME activities; Mrs. Hal W. Hardinge, honored guest, who provided the funds for the award named in honor of her late husband; and C. H. Behre, Jr., professor of economic geology at Columbia University and a business associate of Mr. Dolbear.

SME AND DIVISION AFFAIRS

Seated at the head table at the Coal Division luncheon on Tuesday were E. G. Fox, David R. Mitchell, E. M. Spokes, C. E. Lowall, William McCulloch, George M. Keller, Raymond B. Salvati, Joseph L. Gillson, J. W. Woomer, Carl Hayden, R. G. Lazzell, D. R. Tone.

Roger Enloe, UN We Believe, Inc., speaker at the SME dinner, stops to talk with James C. Gray, SME President-Elect, and Raymond B. Salvati, outgoing chairman of the Coal Division and this year's winner of the Erskine Ramsay Gold Medal.

Nathaniel Arbiter shakes hands with Wayne Dowdey, outgoing MBD chairman as R. R. McNaughton looks on at the MBD luncheon on Thursday in the top picture. Directly above Mr. Dowdey presents the Robert H. Richards Award to Norman L. Weiss, SME director, head of the transactions editorial committee and past-chairman of MBD. Mr. Weiss was principal speaker at the luncheon.

Robert J. Lacy, incoming chairman of M&E; R. H. Feierabend, 1960 chairman, Industrial Minerals Division; A. B. Cummins, SME President for 1960; and H. Rush Spedden, incoming MBD chairman, get together for a chat at SME's dinner Tuesday.

Pictured at the Mining & Exploration Division luncheon on Wednesday are Louis B. Slichter; Lyman Hart, the outgoing chairman of the Division; R. R. McNaughton, AIME President-Elect.

Louis B. Slichter, University of California, this year's Jackling lecturer, receives his award from Richard K. Waring, New Jersey Zinc Co., who introduced Dr. Slichter at the M&E luncheon.

1960 ANNUAL MEETING, NEW YORK

AIME is people and it's the people who spark the Annual Meeting. For those of you who missed the fun, and for those of you who were there and want to recapture the mood, we present a roundup of some of the people to be seen attending the sessions, the luncheons, and especially, the Annual Banquet. Top left: Harry L. Horton, Dow Chemical Co. from the Permian Basin Section; Edward C. Schmid, public relations director, Reserve Mining; and Robert J. Linney, Reserve Mining Co., who as past-chairman of the Minnesota Section accepted the dual award of banner and gavel in the Membership Application contest. Top right: Raymond B. Salvati, winner of the Erskine Ramsay Gold Medal, shakes hands with H. DeWitt Smith, elected an Honorary Member of AIME this year, while Andrew B. Fletcher, another Honorary Member, looks on. Left: Representing the women in the profession as well as being speakers at SME technical sessions are: Margaret F. Boos, a consultant from Denver; Hazel B. Comstock, of the USBM; Pauline Moyd, consultant in Yonkers, N. Y., with Louis Moyd.

Above, left: Harold E. Robbins, Andes Copper Mining Co. and co-author of the M & E paper on the development of the El Salvador Mine giving the highlights of the material in the April issue of MINING ENGINEERING, *shakes hands with R. R. McNaughton, AIME President-Elect. Center: Howard C. Pyle presenting certificate to Hardinge Award winner, Dr. Dolbear. Right: Augustus B. Kinzel, winner of the James Douglas Gold Medal and Union Carbide Corp. Vice-President, accepts congratulations for the honor.*

PEOPLE AT THE MEETING

J. W. Woomer, Past-President of SME, pauses to exchange pleasantries with Louis B. Slichter, this year's winner of the Daniel C. Jackling Award and Lecture which was presented at the Mining & Exploration Division luncheon on Wednesday.

Lester Charles Uren, Emeritus Professor of Petroleum Engineering, this year's winner of the Mineral Industry Education Award, accepts his citation and the congratulations of Howard C. Pyle. AIME Council of Education sessions were held Sunday.

The annual banquet on Wednesday night provided many opportunities for observing people. Above left: Robert J. Linney, Reserve Mining Co., recipient of the William Lawrence Saunders Gold Medal for distinguished achievement in mining other than coal, receives his citation and congratulations from Howard C. Pyle, outgoing President of AIME. Center: Mr. and Mrs. Howard C. Pyle caught in a quiet moment before the banquet. Below: George M. Humphrey, former Secretary of the Treasury of the United States, who was among those named an Honorary Member of AIME previously, shakes hands with Charles McElroy White as he congratulates him on winning the Benjamin F. Fairless Award in recognition of distinguished achievement in iron and steel production. Howard C. Pyle looks on approvingly. At center right, shown addressing the membership, is A. B. Cummins, Johns-Manville Research Center, SME's President who was installed in office during course of the Meeting.

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If you plan to offer a paper . . . . . .

Authors who hope to present a paper at the 1961 Annual Meeting (St. Louis, Feb. 26 through Mar. 2, 1961, Chase-Park Plaza Hotels) should **immediately** contact the appropriate Division program chairmen; see list above. A brief abstract of what you propose will help the committees to reach a decision.

For information on the 1959 Index to MINING ENGINEERING,

turn to *Drift*, page 337.

REMINDER–Return Your Directory Card

University Symposium Volumes Are Available

Because of the great interest expressed in obtaining copies of the *Proceedings* from the 1959 Drilling Symposium, The Center for Continuation Study, University of Minnesota, has released the following information on availability of copies of all of the Drilling Symposiums.

No copies of the first six annual proceedings, 1951 to 1956, are available. Copies of the 1957 and 1958 proceedings on *Exploration Drilling*, and *Production Drilling, Drill Steel and Blasting and Research*, respectively, are available at $7.50 each from The Center for Continuation Study, University of Minnesota, Minneapolis.

Publication of the Third Annual Symposium on *Rock Mechanics*, April 1959, was in the *Quarterly of the Colorado School of Mines*, vol. 54, No. 3, July 1959. This may be ordered from the Director of Publication, Colorado School of Mines, Golden, Colo., for $3.00.

Proceedings of the ninth annual symposium, October 1959, *Exploration Drilling*, are published as Bulletin 72, Experiment Station of the College of Mineral Industries, Pennsylvania State University. This bulletin may be ordered from the Director of Experiment Station for $3.00. Pennsylvania State University is at University Park, Pa.

The Center also announced subjects and locations of forthcoming sessions: October 1960, *Drilling and Blasting Symposium* to be held at the Colorado School of Mines; April 1961, *Rock Mechanics Symposium* to be held at Pennsylvania State University; and October 1961, *Exploration Drilling Symposium* to be held at the University of Minnesota.

Sikkar Receives Prize

Johan Sikkar, a graduate student at Montana School of Mines when he submitted his paper, *An Application of Quality Control in Mining Industry*, has been awarded the prize for the best paper in the United States presented under the Graduate Division of the National Prize Paper Contest, Society of Mining Engineers, AIME.

Mr. Sikkar received his M.S. in mining engineering from the Montana School of Mines in June 1959. He is presently employed by The New Jersey Zinc Co. at Gilman, Colo. Mr. Sikkar was born in Stockholm, Sweden. He received his undergraduate training at the Colorado School of Mines from which he graduated in 1958.

Underground Corrosion Short Course in June

The 5th annual Appalachian Underground Corrosion Short Course will be held June 1, 2, and 3 at The West Virginia University, Morgantown, W. Va. The course covers both technical and nontechnical presentations of the practical and theoretical aspects of corrosion applicable to underground pipe, cable, and water systems covering eight main groups of underground corrosion.

In addition to class room instruction, there will be field demonstrations of coating materials and instruments, exhibits, and movies. A round table discussion is being planned for one of the evening sessions.

Information about the course can be obtained by writing John H. Alm, publicity chairman, Room 605, 2 Gateway Center, Pittsburgh 22, Pa.

AIME Southwest Meet In Los Angeles in April

Metals and Materials for the Space Age will be the general topic for the 1960 AIME Southwest Metals and Minerals Conference April 21 to 23 in Los Angeles at the Ambassador Hotel. Highlights of the program for those interested in mining and rock products will be symposiums on boron and rock products on Thursday, April 21, and three mining sessions on Friday.

Dr. Joseph L. Gillson, President of AIME, will give the welcoming

(Continued on page 396)

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ROCK IN THE BOX

Mining & Exploration Division

Mining and Exploration Division Introduces Its 1960 Officers

The Newsletter is devoted this month to introducing the major officers of the Division. Chairman R. J. Lacy is top officer, presides over division meetings, and conducts its business affairs.

The assistant chairman John G. Hall acts in place of the chairman whenever the latter is unable to be present at Division meetings. He keeps in close touch with the chairman and assists him in any way necessary.

Each of the vice presidents are responsible for one of the following areas: 1) publications, 2) programs, 3) membership. Each coordinates the activities of the Unit committee under his classification. Each also acts as a liaison officer between the M&E and the appropriate officer or committee of SME.

The secretary handles Division "paper work" and any other such business that may be required to keep M&E affairs running smoothly.

Robert J. Lacy, the new chairman of the Division, is chief geophysicist for American Smelting & Refining Co., Salt Lake City. A graduate of the University of Minnesota, he became a mine geologist for the Anaconda Co. in Butte, Mont. upon receiving his degree in mining engineering in 1937. In 1946 he joined the California Co. as a geological observer on exploration parties. He returned to his alma mater in 1947 for postgraduate work, accepting a post as geologist with Asarco the following year.

John G. Hall, assistant chairman, was born in Omaha, Neb. on Jan. 17, 1917. He attended public schools in Nebraska, New Jersey, and Utah and graduated from the University of Utah in 1939 with a degree in mining engineering. Mr. Hall began his career in 1939 with the United States Smelting Refining and Mining Co. as a mucker, mine foreman, geologist, and efficiency engineer in the Tintic and Bingham mining districts. In 1946 he became general superintendent of the Chief Consolidated Mining Co. operations in Eureka, Utah. In 1952 he became assistant plant manager of the National Lead Co.'s titanium plant in Tahawus, N. Y. In 1955 he was appointed plant manager.

A. W. Ness, secretary, is safety engineer for American Smelting and Refining Co. in Salt Lake City. He has an E.M. degree from the University of Minnesota and an LL.B. degree from the LaSalle Extension University. After a year in small gold mining camps near Helena, Mont., Mr. Ness worked for the Anaconda Co. at Butte as a miner, sampler, shift boss, assistant foreman and safety engineer. He then spent a year with USBM and in 1945 he went to work for the Anaconda Co. at Chuquicamata as tunnel and shaft sinking foreman. In 1948 Mr. Ness joined American Smelting and Refining Co. in his present position.

John C. Wangaard, vice chairman in charge of publications, is superintendent of the Cary Mine of the Odanah Iron Co., Hurley, Wis. and the Peterson Mine of the Puritan Mining Co., Bessemer, Mich., both managed by Pickands, Mather and Co. He was born in Minneapolis and graduated from the University of Minnesota School of Mines in 1935. After leaving college he joined Lamaque Mining Co. Ltd. in Quebec. In 1944 he moved to Vermont Copper Co. as chief engineer and later was promoted to mine superintendent. Mr. Wangaard joined Pickands, Mather and Co. in 1951 as an operating assistant in the district office at Ironwood, Mich. He was appointed superintendent of the Cary Mine in 1953 and of the Peterson Mine in 1957.

J. M. Ehrhorn, vice chairman responsible for programs, graduated from Stanford University with a degree in mining engineering in 1927. He gained his early mining experience working as a miner, timberman, and shift boss with United Verde Copper Co., Jerome, Ariz., the North Fork Placer Mines at Helena, Calif., and the Idaho Maryland Mines Corp. in Grass Valley, Calif. between 1927 and 1938. In 1938 he formed a partnership with H. F. Lynn and entered the consulting field as an engineer and geologist. In May 1942 he joined Western Knapp Engineering Co. as mine plant construction superintendent and for two years was in charge of field construction projects in California, New Mexico, and Colorado. He joined United States Smelting Refining and Mining Co. as industrial relations engineer in April 1944, was advanced to superintendent of the U.S. Section of the U.S. and Lake Mine in September 1945. In July 1951 he was made assistant to the manager of mines and in 1953 he was promoted to his present position as industrial development director.

Peter Joralemon, vice chairman of membership, received his education at Yale University from which he received his B.S. in 1943 and at Harvard University from which he received both an M.A. and a Ph.D. in 1949. From 1943 to 1946 he was a geologist with USGS. From 1949 to 1950 he was geologist at Getchell Mine in Nevada and for the next five years he was with the New Park Mining Co. as geologist and later as superintendent. From 1955 on he has been a consulting geologist. He has been a member of the board of directors of New Park Mining Co. and the the Lucky Mc Uranium Co.

R. J. LACY

J. G. HALL

A. W. NESS

J. C. WANGAARD

J. M. EHRHORN

P. JORALEMON

IndMD Reveals Propose Changes in Its Bylaws

Since the Industrial Minerals Division Bylaws were published and approved in January 1959, a number of discrepancies in wording and intent seem to have developed. Accordingly, this past year, John Broughton, chairman of the Division for 1959 to 1960, appointed a committee to 1) review the Bylaws, 2) make certain corrections in language, and 3) make recommendations for changes in some sections to clarify their meaning.

G. Donald Emigh, director of mining for Monsanto Chemical Co. in St. Louis, was chairman of this committee. He was ably assisted by Frank R. Hunter, chief geologist for International Minerals & Chemical Corp., and John B. Patton, principal geologist for the Indiana Geological Survey. The committee presented its report at the Annual Meeting, Feb. 16, 1960. The changes were thoroughly discussed in the Executive Committee meeting and were unanimously approved. The changes as recommended and approved by the Executive Committee appear below:

Article II

Members

The section was changed to read:
Section 1. Any member of the AIME in good standing may become a member of this Division, through membership in the SME, by written notification to the Secretary of the Institute.

Article IV

Meetings

Section 1. and 2.
Both sections were changed to start with:
"An annual. . ."
Section 3.
The present wording ". . . not inconsistent with these Bylaws or with the Bylaws of the Society of Mining Engineers." was changed to read:

". . . as may properly come before the meeting."

Article V

Officers and Government

The start of the first sentence was changed to read:
Section 1. The officers of the Division shall be Chairman, . . .

The last section of the section (now enclosed in parentheses) reading: "(Currently the Division . . . Southwest area.)" was eliminated.

This section was changed to read: **Section 3.** The Executive Committee shall consist of the Chairman, the Vice Chairmen, Secretary-Treasurer, Past-Chairman, ex-officiis, and a maximum of 12 members, all of whom (except the Past-Chairman) shall be nominated and elected as provided hereafter in **Article VIII.**

The second sentence of the section was changed to read: **Section 4.** The officers of the Division shall be. . . **Section 7.**

The section was reworded and moved to **Article VII,** where it became **Section 4.** (See **Article VII** for revised text).

Article VI

Committees

The section was changed to read: **Section 1.** There shall be the following Standing Committees: Nominating, Membership, Program, and such technical committees as may be authorized by the Executive Committee. In addition, there shall be a Division Publications Committee, auxiliary to the Editorial Board of the Society of Mining Engineers of AIME.

The entire second sentence of the section was eliminated and the first sentence was changed to read: **Section 2.** The Chairman of the Division shall appoint the Committee Chairmen.

A new section was added as follows:

Section 3. The nominating Committee shall be made up, where possible, of the most recent Divisional Past-Chairmen.

Article VII

Nomination and Election of Officers and Appointment of Committees

A sentence was inserted after the third sentence (ending ". . .October issue of MINING ENGINEERING.") and the text of the last sentence was changed. The text now reads:

Section 2. ". . . MINING ENGINEERING. The Chairman of the Technical Publications Committee shall take office October 15 each year. If such other nominations are made, an election shall be held by letter ballot to be completed by December 31. If no such additional nominations are received, the candidates nominated by the Nominating Committee shall be considered elected and shall take office at the next Annual Meeting.

A new section (altered from **Section 7, Article V**) was inserted to read as follows:

Section 4. In accordance with **Article V** of the Bylaws of the Society of Mining Engineers of AIME, a member of the Division shall be elected by secret ballot of the Executive Committee each year to serve for three years as a representative of the Industrial Minerals Division on the Board of Directors of the Society. If he is not already a member of the Executive Committee of the Industrial Minerals Division, he shall thereby become a member.

Division members are asked to vote upon these changes in the IndMD Bylaws. Please mark the ballot above and mail it no later than midnight May 15.

Bylaws

Don't forget to vote; mark, sign, and mail the ballot now.

Industrial Minerals Division Members

VOTE NOW

Please signify your approval or disapproval of the proposed Bylaw changes by marking an X in the proper box below. **Sign and return this ballot** (before midnight, May 15) to: *J. S. Holland, IndMD Secretary-Treasurer, National Lead Co., 111 Broadway, New York 6, N. Y.*

I approve the proposed changes in the IndMD Bylaws as published in the April 1960 issue of MINING ENGINEERING

☐ YES ☐ NO Signed: _____

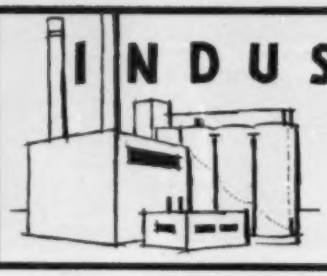
Note: Ballots will be invalid unless marked, signed, and postmarked no later than midnight, May 15, 1960.

WAAIME Flower Fund

The Woman's Auxiliary of AIME calls attention to its Flower Memorial Fund, a part of its Educational Fund, as a means of honoring the memory of a deceased friend or relative by contributing to the education of a student in mining, metallurgy, and petroleum.

Contributions to the Fund are acknowledged through inscription of the donor's name and that of the deceased in The Flower Memorial Book and a card sent to the donor and to the family of the bereaved. In arranging for a memorial it is therefore necessary to remember to include the name and address of the person in the bereaved family to whom the card is to be sent. Check should be made payable to the WAAIME Educational Fund, Flower Memorial, and sent to Mrs. Edward H. Thaete, Schuyler House, Fort Hill Village, Scarsdale, N. Y.

The fund was established in 1954 and with the addition of $1819.00 during 1959, the resources of the Flower Fund stand at $6100.00.



INDUSTRIAL MINERALS NEWSLETTER

Dear Members of IndMD:

We are a full month later than intended reporting to you the results of our Executive Committee meeting held during the annual get-together in New York last February. Time, they say, has a way of softening the vivid primary colors into pastels and a way of mellowing even the most caustic of us into a kindly philosopher. Time enough has not elapsed since the meeting to take the edge off what we believe was the liveliest (if not the best) Executive Committee meeting in many a moon. There were times when your chairman, new in his job, would have felt more secure with a pearl-handled six-shooter for a gavel than the glass ashtray he was using. Come to think of it, too, a parliamentarian would have come in handy! It was one of those affairs when everybody—including the spectators—had his say, and for good reason.

Among the major items of business, action was taken to streamline and clarify our Bylaws. Changes adopted by the Executive Committee and recommended for membership approval appear elsewhere (on page 394) in this issue. Don Emigh, Frank Hunter, and John Patton did a fine job on a difficult and somewhat prosaic but highly important assignment.

Program Committee Changed

By far the most important item on the agenda was the *Lund Report*. Your 1959 chairman, John Broughton, recognized the increasing difficulty of effectively planning programs and membership drives under the present cumbersome, short-term commodity committee setup. He asked R. J. (Dick) Lund of Battelle Institute to head a committee to study the problem and to recommend a course of action which would both streamline and revitalize our operating organization. Dick was fortunate to get the help of a group of our elder statesmen, most of them past-chairmen of the Division: Harold Bannerman, Ray Ladoo, Howard Meyerhoff, and Bob Stephenson. Although the committee (and spectators) could not agree on all points in the Lund report, all present at the meeting agreed that the subcommittee had done yeoman service, knowing they were treading in dangerous territory and were likely to be severely criticized for some of their conclusions. To quote from Leon Dupuy's minutes, here are the result.

> "After long and spirited discussion, a motion was made, seconded, and adopted by majority vote that the first six items of the recommendations of the subcommittee be accepted in principle and that a subcommittee be appointed to work out details. The subcommittee is to report at the next meeting of the executive Committee. The six items are as follows:
>
> 1) That the present commodity committees, as such, be abolished.
> 2) That for programming purposes, the various industrial mineral commodities be grouped into six classes, as follows:
>
> I. Minerals for Construction Materials
> II. Minerals for Chemicals and Chemical Processes
> III. Minerals for Ceramics and Refractories
> IV. Minerals for Fillers, Filters, and Abrasives
> V. Industrial Waters
> VI. Minerals for Special Uses
>
> 3) That the present Divisional Program Committee be changed to a Program Policy Committee composed of six members, one drawn from each of the six commodity classes.
> 4) That the members of this committee be appointed, on a rotational basis, each to serve for three years (i.e., that two members retire and two successors be appointed each year).
> 5) That each year the chairman-elect of the Division designate the two senior-in-service members of the Program Policy Committee to serve as program chairman and vice chairman, respectively, for his term of office, and hold them responsible for formulating the Division program for that year.
> 6) That the chairman of the Program Policy Committee be empowered to appoint such ad-hoc subcommittees within the framework of the six commodity classes, as may be needed to work up the details of the technical program. (Generally the subcommittee members would be drawn from the ranks of the commodity classes represented by the chairman and vice chairman, respectively. These classes will be expected, therefore, to bear the major responsibility for organizing and running the program for the year, but the Program Policy Committee should be empowered to call upon any of the classes to contribute program items on topics that, in the opinion of the committee, are deemed of special or timely interest.)"

Your chairman is now (mid-March) lining up a subcommittee to prepare an outline for an operating manual. We expect to have the plan in operation in the 1961 Division year.

St. Louis, 1961

Dick Lund, our current program chairman, reported plans are already well underway for the 1961 meeting in St. Louis.

Tentative session themes include:

1) Chemical Industry in the Midwest
2) Transportation of Bulky Industrial Minerals
3) Conflicting Interests in Resource Development
4) Foreign Trade Aspects of Fillers, Fibers, and Pigments
5) Industrial Waters

A sixth session, devoted to topics of current interest not covered by the other five, is also under consideration.

Get in touch with Dick Lund or the Commodity Committee chairmen if you have ideas and suggestions.—*R. H. Feierabend*

EJC Announces Officers

According to a recent announcement by the Engineers Joint Council, Augustus B. Kinzel, Past-President of AIME, was elected 1960 president and Cecil Boling was elected vice president. Following the resignation of Esworthy P. Lange to become executive secretary of the American Inst. of Industrial Engineers, Leroy K. Wheelock was elected secretary. Mr. Wheelock has been assistant secretary of EJC since 1956.

Southwest Meeting

(Continued from page 392)

address at Thursday's luncheon. His subject will be *Industrial Minerals in the Southwest*. Albert C. Hibbs, acting chief, Div. of Space Sciences, Jet Propulsion Laboratory, will be the speaker at the banquet Thursday night. He will talk on *The Exploration of Space*.

Field trips and activities for the ladies have also been planned.

Paul Merritt Joins Staff As Technical Editor

As the new Technical Editor for MINING ENGINEERING, Paul C. Merritt brings a strong interest in the colorful business of mining as well as more formal training in exploration and business administration.

Although he was born in Michigan his family soon moved and he began his education in New Jersey and continued it in California. But Paul says his closest ties today are to Cape Cod, where his family resides. After two

years at Pomona College in California, he transferred to Middlebury College in Vermont where he received his B.A. in geology (cum laude, high honors) in 1953. Subsequently, he received an M.A. in economic geology from Columbia University.

Field work with Bear Creek Mining Co. in northeastern New England was followed by two years in the U. S. Army, spent largely in France. Then, more field work with Amerada Petroleum Corp. in North Dakota before taking graduate work at Harvard University School of Business Administration.

At the time he joined SME he was working with an investment counciling firm in Boston. A bachelor, Paul's varied interests include skin-diving and mineral collecting.

Uranium Symposium

The program for the 1960 Uranium Symposium at Moab, Utah is beginning to take shape. Maurice H. Brady, secretary-treasurer of the Uranium Section, has announced that the following sessions and speakers have been confirmed:

Mining

The Motorized Wheel, R. W. Volpe, General Electric Co.
Shaft Sinking at Ambrosia Lake, Mitchell Kline, Rare Metals Corp.
The Steel Strike Issues and their Final Resolution, C. T. Spivey, U.S. Steel.

Mining Forum

The Yieldable Steel Arch and Fill Program at the Sunnyside Mines, Joe Taylor, Kaiser Steel Corp.
Pillar Extraction in Ambrosia Lake District, Dave Turberville, Rio De Oro Mining Co.
The Alimak Raise Climber, Gordon Bruckner, Standard Uranium Corp.
The Transloader, John Currier, American Zinc, Lead & Smelting Co.

Geology

Geology and Ore Controls, Pitch Mine, Saguache Co., Colo., B. C. Scott.
Mine Evaluation with the Russian Head, Mele Crewe.
Geology of the Orphan Lode Mine, Grand Canyon, Ariz., speaker unnamed.

Milling

Process Control at Eldorado's Beaverlodge Mill, Beaverlodge staff.

The other milling papers have not yet been confirmed nor has the geology forum. On the agenda of the milling forum are a discussion on molybdenum control in uranium circuits and P.M. Thomas, Western Nuclear Corp., will talk on continuous ammonia precipitation.

Roy Hollis will be moderator for the milling forum, and Miles Rommey will be moderator for the mining forum. A moderator for the geology forum is not yet set.

Salt Lake Plays Host To Rocky Mount Meet

Two planning meetings have been held for the 6th annual Rocky Mountain Minerals Conference to be held at the Newhouse Hotel, Salt Lake City, Oct. 5, 6, and 7, 1960.

J. M. Ehrhorn, general chairman, has announced the following tentative program: Registration will take place on October 4, 5, and 6. On October 5 there will be technical sessions, ladies' coffee, a welcoming luncheon, and a manufacturers' cocktail party.

In addition to technical sessions on October 6, there will be a minerals luncheon and ladies show and luncheon.

A miners' breakfast, technical symposium, field trips, and concluding dinner-dance will take place on October 7.

Richard L. Stewart is publicity chairman for the meeting.

James Irvine Attends President's Safety Meet

President Eisenhower invited James C. Irvine, a student in mining engineering, College of Engineering, University of Kentucky and an AIME student member, to attend the President's Conference on Occupational Safety held in Washington, D. C. March 1 to 3.

The Conference brought together more than 3000 leaders from American industry, labor, agriculture, federal, state, and local governments, insurance, education, health, and private safety organizations from all parts of the country to devise and apply voluntary cooperative means for reducing the 13,300 deaths and nearly 2 million disabling injuries occurring annually because of on-the-job accidents.

Delegates to the Conference examined problems arising out of new and intensified safety and health hazards throughout the U.S. economy. This effort is summarized in the conference theme: *The Challenge of Safety in a Changing World* with emphasis upon broad functional topics pointed toward new hazards during the decade of

(Continued on page 411)

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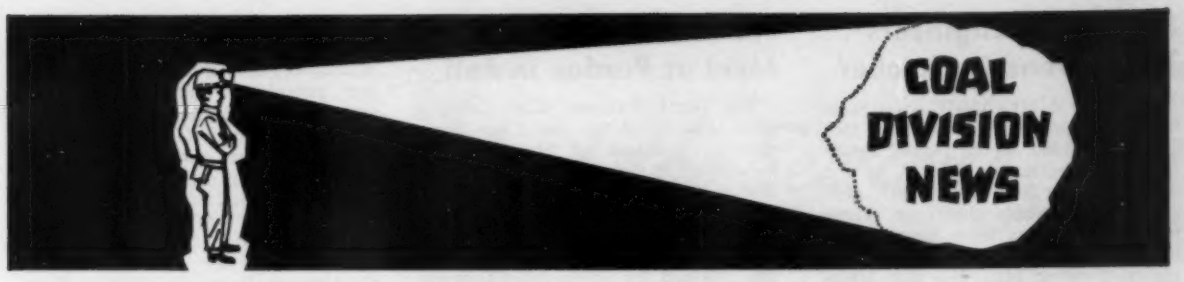

Leading U.S. Mining Schools . . .
University of Kentucky at Lexington

Since 1904, mining engineering graduates of the University of Kentucky have been entering industry; however, instruction in mining was provided when the University was founded in 1865. Because of the importance of bituminous mining in the state, primary interest has been in coal; but an appreciable portion of the graduates enter the petroleum, metal, and nonmetallic branches of the industry, both in and out of the state and in foreign countries.

To meet the needs of this varied group, the curriculum in mining is a broad one, and the student may strengthen his special interests by his choice of electives. The curriculum is revised periodically to introduce the latest concepts and eliminate the obsolete as mining goes to greater depths, thinner seams, and leaner ores. Field trips, laboratories, and summer employment emphasize the importance of practical application of theory, and it is a rare student who graduates without several months of paid underground experience.

A graduate program for the master's degree has prepared men with special training and research experience. In recent years they have worked on coal preparation, coking, low temperature carbonization, ventilation, industrial engineering applications, stream pollution control, design of mining machines, and continuous miner operations. Practical research experience is available for undergraduates working as technicians for a variety of graduate programs.

A 50-lb plumb bob for shaft plumbing is compared with an instrument bob, underground, by one of the student engineers.

Field trips give the mining students opportunity to observe a variety of operations.

The University is located at Lexington, in the middle of the state. It is midway between the eastern and western coal fields, and within a day's travel of a variety of metal and nonmetallic mines. Oil fields are quite close, and a shaft-opened limestone mine two miles from the campus provides the students with their first underground training in surveying classes.

The Norwood Mining and Metallurgical Soc. introduces the student to AIME. Speakers from the campus and industry help broaden the student's outlook and provide another contact with the practical aspects of mining. Writing articles for the college's *Kentucky Engineer* gives an introduction to the preparation of papers for presentation at professional meetings.

The department staff includes three mining engineers with a breadth of practical experience which allows a close attention to the individual inclination of the student. The metallurgy staff, graduate assistants, and laboratory and shop technicians provide help for the mining students on special problems.

Close liaison is maintained with the Kentucky Dept. of Mines and Minerals and the Kentucky Geological Survey, both of which are located on campus. Work opportunities, expert advice, reference materials, and a variety of equipment are made available by these organizations. Mine rescue and first aid training are provided by the USBM and the Dept. of Mines and Minerals; statewide competitions on the campus increase the student's interest in safety.

Strong emphasis is placed on economic aspects of engineering, management, and professional quality of work. Students are encouraged to take the engineer-in-training examination in preparation for eventual registration so they may be qualified to serve as chief engineers. The students is developed for leadership in industry and the community, hence his training includes practice in written and oral expression, discussion of current issues as they relate to the mineral industry, and courses in various liberal arts areas.

St. Louis Fall Meeting

Division members are reminded of scheduled fall meetings: the Coal Division-St. Louis Section in September and the annual AIME-ASME Joint Solid Fuels Conference in October (page 398).

The Coal-St. Louis meeting will take place on September 8 and 9 at the Chase-Park Plaza Hotels. W. A. Weimer, Peabody Coal Co., is general arrangements chairman.

Students develop skill in mine surveying.

Solid Fuels Engineers To Convene in October

The 1960 AIME-ASME Joint Solid Fuels Conference will be held Oct. 24 and 25, 1960, at the Daniel Boone Hotel in Charleston, W. Va., it was announced by Dale C. Calhoun, general arrangements chairman. Three technical sessions have been scheduled for the meeting: one the morning of October 24th, one that afternoon, and one the morning of October 25th. A plant trip is scheduled for the afternoon of the 25th. The theme of the conference will be *Economic—Production and Utilization of Coal.*

Ninth National Clay Meet at Purdue in Fall

The Ninth National Clay Conference, sponsored by the Clay Minerals Committee of the National Academy of Sciences-National Research Council, will be held at Purdue University, Lafayette, Ind., October 6, 7, and 8. In addition, a short field trip and laboratory visits are planned for Wednesday October 5.

Two special symposia of invitational papers are planned on Engineering Aspects of Physico-Chemical Properties of Clays which will feature contributions on soil mechanics and Clay Organic Complexes which will concern itself with basic studies of clay-organic systems in the paper and petroleum industries, in soil science, civil engineering and other areas. In addition, there will be general sessions, and original contributions on any aspect of clay mineralogy are invited.

The Union Club of the Purdue Memorial Union has adequate accommodations for all attending the Conference. However, additional accommodations are available at local hotels and motels. For further details write: *Dr. J. L. White, Ninth National Clay Conference, Agronomy Dept., Purdue University, Lafayette, Ind.*

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Sedwick Receives Award

Herbert P. Sedwick received the 1960 Washington Award of the Western Soc. of Engineers at a presentation dinner February 29 in the Furniture Club of America. He was honored for leadership and achievement in electric and gas utilities, for true service in educational and humanitarian fields and for developing young engineers.

Mr. Sedwick retired in 1958 as president of the Public Service Co. Div. He was also executive vice president of Commonwealth Edison Co. and still serves as director of the utility. He is past-president and honorary member of the Western Soc. of Engineers. In 1958 he was cited as *engineer of the year* by the Chicago chapter of the Illinois Soc. of Professional Engineers.

EMC Announces Officers

The Engineering Manpower Commission of Engineers Joint Council recently announced the re-election of Julian W. Feiss, staff geologist, Kennecott Copper Corp., as chairman of the Commission for 1960. Re-elected vice chairman was S. B. Ingram, director of education and training, Bell Telephone Laboratories. New members of EMC include Brig. Gen. H. K. Kelley, USAF, Alexandria, Va.; and G. R. Henninger, Ohio College of Applied Science, Cincinnati.

World Power Meeting To Be Held in Madrid

The Madrid Sectional Meeting of the World Power Conference will take place from June 5 to 9. Methods for solving power shortage problems has been chosen as the general theme of the meeting in view of the universal desire to increase the traditional sources of power, or replace them by others. The technical sessions will be held on the premises of the National Institute of Industry, Madrid.

Around the Sections

• The **Uranium Section** met at the M4 Ranch January 6. Louis Allevato, sales engineer for the Link-Belt Co. of San Francisco, gave a talk and showed a film on waste disposal. He was assisted by William Preston of the Salt Lake City branch of the company.

Directors elected for 1960 and 1961 were: Charles Brechtel, Harold Blakely, and T. F. Izzo; others are John Mullen, and Ted Barrett. Committee chairmen are Ted Izzo, symposium; R. W. Unger, program; Harold Blakely, membership; Gordon Miner, building fund; Robert Norman, publicity; and Robert Curfman, parliamentary.

• **Ajo Subsection,** Arizona Section, held their January 14 meeting at the Copper Coffee Shop. H. C. Weed, general manager, Inspiration Consolidated Copper Co. and vice-president, Society of Mining Engineers, was guest speaker. He spoke on AIME affairs and mining at Inspiration.

• The **Eastern North Carolina Subsection,** Southeast Section, met February 6 at Harvey's Cafeteria, Durham, N. C. Harry M. Peet, chief, Div. of Ground Water, N. C. Dept. of Water Resources, spoke about the organization, plans, and problems of his newly formed division.

• The **Mining Subsection,** Minnesota Section, held a joint meeting with the members of the Lake Superior Geology Club at the Androy Hotel in Hibbing, Minn., February 3. Professors Pfleider and Yardley of the University of Minnesota were guest speakers. Their presentation of *The Underground Mining of Taconites* was illustrated with slides.

• The **Colorado Plateau Section** reported the election of the following officers: T. S. Ary, chairman; C. H. Reynolds, vice chairman (membership); Mark Shipman, vice chairman (program); and Carl W. Appelin, secretary-treasurer. Directors are Robert Ward, George Morehouse, R. C. Robeck, and G. C. Ritter.

• Dr. LeRoy Scharon, professor of geophysics, Washington University, discussed four techniques of geophysical prospecting that hold significant opportunities for future development at the **St. Louis Section** meeting January 8. The four areas covered were gravimetric, seismic, magnetic, and electronic instruments.

• **Washington State University Student Chapter** met on the campus on December 15. Dave Stiefbold, a graduate student, presented pictures taken during his travels in Europe and the Middle East.

• Carl H. Samans was elected chairman of the **Chicago Section.** He is director of the engineering materials division of the research and development department of Standard Oil Co. (Indiana).

Proceedings are underway to effect the reorganization of the Chicago Section. The primary change planned is to have separate meetings for Institute of Metals of TMS members and separate meetings for SME members in an attempt to make the meetings more interesting to members who are not metallurgists.

• The topic of discussion at the **Utah Section** meeting held at the Newhouse Hotel, January 25, was Bear Creek Mining Co.'s East Tintic Pb-Zn development. The speakers were D. R. Cook and J. B. Bush, geologists with Bear Creek.

Glen A. Burt was presented with his past-chairman's pin and Gail Hansen received a pin and check for having obtained five new members in 1959.

• The **New York Section** heard George E. Evans, director of research, Union Carbide Consumer Products Co., speak on *The Fuel Cell* at their November 1959 meeting in the Miner's Club.

L. G. Bliss, president, Foote Mineral Co. was guest speaker at the January 1960 meeting. His topic was *Lithium—Present Trends in Research, Development and Application.*

The Section announced the following officers for this year: George P. Lutjen, chairman; Louis Pierre Ledoux and H. Myles Jacob, vice chairmen; Alan R. Reiser, treasurer; and Robert J. Searls, secretary. Committeemen are Ralph L. Hennebach, Thomas Graham, Howard Barkell, Kenneth W. Palmer, Norman H. Donald, Jr., and A. F. Banfield.

• New officers for the **San Francisco Section** are: Peter Joralemon, chairman, and Evan Just, vice chairman.

The Section's annual dinner-dance, held in conjunction with the Women's Auxiliary, took place March 12 at the Mark Hopkins Hotel.

• The **El Paso Section** met at the Hotel Cortez, January 13 to hear Charles E. McIntyre of the El Paso Natural Gas Products Co. talk on *The Oil Game.*

The following officers were elected at this meeting: Paul H. Hale, chairman; Victor LaFave, vice chairman; Guy E. Ingersoll, secretary-treasurer; directors: Ames D. Bradish, John E. Douglas, Henry Bernard Hanson, Romney J. Mellen, F. Keith Peyton, Billy H. Spoon, and Eugene M. Thomas; and alternate section delegate, Guy E. Ingersoll.

• The **Lima, Peru, Section** met for lunch December 16 at the Hotel Bolivar where Dr. Alejandro Desmaison spoke to them on *Commentary on the Laws of Industrial Production.*

At the January 20 meeting the Section heard Ing. Mario Samamé Boggio of the Universidad Nacional de Ingenieria discuss *Mining Engineering Education in Chile.*

• The first meeting of the year of the **Southeast Section** was held January 27 at the Thomas Jefferson Hotel in Birmingham. Walter B. Jones, State Geologist, Geological Survey of Alabama, spoke on the progress in the oil industry for the past several years and other mineral resources of the state.

New officers for the year were installed: E. P. Reed, chairman; H. W. Kendall, first vice chairman; J. W. Nicol, second vice chairman; and L. S. Chabot, secretary-treasurer.

Southeast Section officers, left to right, are: W. R. Kirkwood, retiring vice chairman; E. P. Reed, chairman; J. W. Nicol, vice chairman; L. S. Chabot, secretary-treasurer. Below: Social hour at the January meeting of the Section in Birmingham.

Personals

J. T. WHETTON

J. W. FRANKLIN

J. T. Whetton, professor at the University of Leeds, Yorkshire, England, has spent eight weeks in Canada on a visiting lectureship provided jointly by the Nuffield Foundation of Great Britain, the National Research Council of Canada, and the universities concerned. After completing his Canadian visit, Professor Whetton proceeded to New York where he visited the School of Mines, Columbia University, before embarking for Trinidad and a visit to operations of Shell Oil Co. In addition to his post as professor, he is head of the mining department at Leeds and has done considerable consulting work in many phases of coal and industrial minerals. Professor Whetton is the author of over 40 research and general papers on mining and allied sciences.

James W. Franklin who had been associate editor of ENGINEERING AND MINING JOURNAL for the past five years has joined International Business Machines Corp. as an editor.

Howland Bancroft, active in geological and mining work since 1907, has retired from the board of directors of Cerro de Pasco Corp. on which he had served since 1950.

William C. McCulloch has become president of Roberts & Schaefer Div., Thompson-Starrett Co. Inc., Chicago operation. The activities of Roberts & Schaefer have been separated into two fields: engineering and construction of coal preparation facilities and related material handling equipment fields, centered in Chicago, and into architectural and engineering work performed mostly in New York and Los Angeles. In addition to the appointment of Mr. McCulloch as head of the Chicago management group, **R. G. Miller, Jr.,** has been appointed vice president-sales; **Joseph F. Peyronnin,** vice president-operations; and **William A. Mullen,** vice president-treasurer. Mr. McCulloch, since 1941 preparation manager of Roberts & Schaeffer, is chairman-elect of the SME Coal Div.

Ralph J. Long, of Utah Construction & Mining Co., has transferred from mine manager, open pit coal, to the Cedar City iron mining operations as manager.

Sherman D. Gardner has joined Monsanto Chemical Co., Soda Springs, Idaho, as an engineer. He was formerly geologist for Rare Metals Corp. of America.

American Cyanamid Co. recently announced that **Tomas E. Rojas** of their Lima, Peru, office will act as assistant to **Herman Hartjens,** recently appointed technical director.

After three years as staff mining engineer with Bethlehem Steel Co., **H. G. Fleshman** has joined Kaiser Aluminum & Chemical Corp. as senior mining engineer.

Theodore F. Berthelote recently joined Joy Manufacturing Co. as a sales engineer after three years as a weather forecaster with the U. S. Air Force.

Robert C. Bryant has set up a consulting service in Fairbanks to serve all of the interior of Alaska (north

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

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Address

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PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Name .....

Former Company .....

Former Title ..... Length of Time There .....

New Company .....

New Title ..... Date of Change .....

.....

Any recent activity that would be of interest to members:

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of Anchorage and the Alaska Range) offering services in geological engineering, groundwater geology, mining geology, and in exploration of minerals and petroleum. He had been exploration geologist for the Tela Railroad Co.

A new firm of consulting engineers, Dorr Consultants, has been formed to provide engineering, financial, and management services to the chemical process, textile, and metallurgical industries. The founding partners are: **John Van Nostrand Dorr, Arthur K. Doolittle, Donald F. Othmer, W. George Parks,** and **William E. Rudolph.** Headquarters of the new organization are at 99 Park Ave., New York.

Keith O'Donnell has been appointed assistant general manager in charge of operations for Frontino Gold Mines in Columbia.

Cooper H. Wayman was recently promoted from senior technologist to supervisor of petrography and mineral technology research, Applied Research Laboratory, U. S. Steel Corp., Monroeville, Pa.

Richard M. Foose, chairman, department of earth sciences, Stanford Research Inst., Menlo Park, Calif. served as one of the technical experts to the United States Delegation Conference on Nuclear Test Suspension Nov. 25 to Dec. 19, 1959 in Geneva, Switzerland.

Allan M. Short, consulting geologist, Golden, Colo., spent January and February making an industrial survey in Puerto Rico.

As of Nov. 1, 1959, **George E. Aiken** was appointed superintendent of production and mining, Cerro Bolivar.

John B. Patton has been appointed chairman of the Dept. of Geology at Indiana University and State Geologist of Indiana. He has been serving in an acting capacity in both positions since the death of **Charles F. Deiss** in June 1959. Dr. Patton received his training at Indiana University and has been a member of its teaching staff since 1947. He has been principal geologist of the Geological Survey since 1952.

R. E. Zimmerman has joined Koppers Co. Inc. as sales engineer. His first major assignment with the firm takes him to Italy in connection with Koppers' contracts with ILVA. Mr. Zimmermann was formerly superintendent of the B. F. Div. of Eastern Gas & Fuel Assoc.

Joseph F. McDonald, Jr., formerly on the staff of U. S. Senator, Alan Bible of Nevada, has set up his own law practice in Reno, Nev.

The closing of the AEC uranium processing plant at Monticello, Utah, has resulted in the transfer of **G. K. Coates** to a field office in Grand Junction, Colo., under the Winchester Laboratory, working with all uranium plants on evaluation and control of radiation as associated with the processing of uranium ore.

The Chain Belt Co., Milwaukee, recently announced the appointment of **J. Walter Snavely,** as assistant district sales manager of its Milwaukee district sales office. Mr. Snavely joined the company in 1927 and was marketing manager of its conveyor equipment before this new appointment.

William F. Keyes, USBM, who had been serving as minerals advisor to the Cuban government, has taken the post of regional minerals officer, American Consulate General, Johannesburg, Union of South Africa.

Julio Ruiz Ocampo has joined Perforadora Walters S. A. as administrator. He had been superintendent for Minera de Mercurio.

Arthur H. Brownlow has accepted a post as assistant professor of geology at the Missouri School of Mines & Metallurgy. He had received his Ph.D. in geology from MIT in February 1960.

Renato G. Bautista has taken a position as research assistant, department of mining and metallurgy, University of Wisconsin.

John H. Schilling mining geologist with the New Mexico Bureau of Mines, has moved to the Nevada Bureau of Mines, serving in the same capacity.

Harold C. Carter has joined the Alcoa Exploration Co. in the Dominican Republic as assistant mining superintendent.

Richard L. Terry has been transferred from the Marcona Mining Co. project in Peru to the Utah Construction Co. project in Chihuahua, Mexico, as project manager.

Glen B. Wilson, formerly pit production foreman for Kennecott Copper Corp. at Ray, Ariz., has gone to Permanente Cement Co. of California as quarry superintendent.

After 43 years of service **N. Isenberg** retired as chief chemist, coke production, for Inland Steel Co., East Chicago, Ind., on Feb. 1, 1960. He is now consultant on carbonization with the Freeman Coal Mining Corp., Chicago.

R. Norman Holme has returned to Lima, Peru, as technical service metallurgist and mining chemicals representative for Dow Chemical International Ltd. S.A. after undergoing a training program of several months in the U. S. Mr. Holme had been with Mauricio Hochschild & Cia. Ltd. S.A. in Lima as assistant chief metallurgist.

David C. Minton, vice president of Battelle Memorial Institute, addressing a convocation at the University of Arizona College of Mines at which he received a Medallion of Merit, told students the nation's minerals industry needs some of the pioneering zeal of the miners in the early days of the West.

"We need a perspective that sees not only the real troubles of the minerals industry, but also the opportunities for a brighter future," he said and indicated research must play an important role in such a new perspective to develop new products and to reduce costs in mining, concentrating, smelting, and fabricating.

Pedro Portaro U., formerly mill superintendent for Banco Minero del Peru, Morococha, Peru, is now with Compania Minera Atacocha, Cerro de Pasco, Peru, in the same capacity.

John B. Malcolm is now mine superintendent for the Tungsten Mining Corp. near Henderson, N. C.

John W. Donaldson, formerly sales engineer for Canadian Vickers Ltd., has joined Strategic Udy Processes Inc., Niagara Falls, N. Y., as an engineer.

Joe D. Terrill, formerly shift foreman at El Salvador, Chile, has left Andes Copper Mining Co. to join American Smelting and Refining Co. at the Santa Barbara Unit in Mexico as exploration and development foreman.

H. VAN HOUTEN

J. V. KERN

Herman Van Houten recently was elected vice president and general manager of the Mining and Construction Div. of Joy Manufacturing Co. For the past two years Mr. Van Houten had been assistant to the president.

Joe V. Kern has been named assistant to the resident manager of the United States Borax & Chemical Corp. potash mines and refinery at Carlsbad, N. M. Mr. Kern had been serving as field accountant before his promotion.

Charles B. Belt, Jr., is on the staff of the dept. of mining & geological engineering at the University of Utah, Salt Lake City.

The appointment of **Norton Jackson,** manager, mining chemicals department, Cyanamid Australian Pty. Ltd., to its membership was recently announced by the Federal Council of

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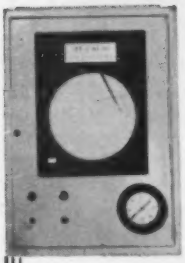

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personals

continued

the Royal Australian Chemical Inst. Mr. Jackson will serve as the representative for South Australia.

Tom N. Rushton has joined the USBM in Minneapolis as extractive metallurgist. He had been a trainee with Climax Molybdenum Co., Climax, Colo.

St. Joseph Lead Co. recently announced executive changes due to the normal retirement of its senior officers. **Francis Cameron** was elected president, succeeding **Andrew Fletcher,** who was elected chairman of the board, an office which has been vacant since the retirement of the late **Clinton H. Crane** in 1957. **Robert H. Ramsey** and **Lawrason Riggs, III,** were elected vice presidents of the company.

At the same time the company announced the retirement of **George I. Brigden, R. J. Mechin,** and **Felix E. Wormser** as vice presidents. Mr. Brigden will continue with the company as a trustee, a member of the finance committee, and as a consultant on financial and tax matters. Mr. Mechin will continue as consultant to the company on South American matters and Mr. Wormser also will remain available to the company for consultation.

John Kyle Gustafson, a member of the U. S. Atomic Energy Commission since 1947, was among 12 outstanding Washington University alumni to receive alumni federation citations at Founders Day ceremonies February 21 held in Graham Memorial Chapel on the college campus in St. Louis.

The Anaconda Co. announced the transfer of **Roland J. Lapee,** a metallurgist at the Great Falls Reduction Works, to the New York office as an assistant to the metallurgical manager.

William H. Swan, formerly assistant plant manager for Pacific Northwest Alloys Inc., where he had been for ten years, has joined Montana Ferro Alloys Inc. as plant manager. Both companies are subsidiaries of Chromium Mining & Smelting.

A. S. Kromer has become president and general manager of Flexonics Corp. a subsidiary of Calumet & Hecla Inc. He had formerly served as vice president and general manager of the Calumet Div. of Calumet & Hecla Inc.

Floyd W. Erickson has gone to Monrovia, Liberia, as president of Mine Management Assocs. Ltd. He had been manager of the Babbitt Div. of Reserve Mining Co.

After six months in the engineering department of New Dickenson Mines Ltd., Balmertown, Ont., **Donald H. Buchholz** has become assistant mine geologist.

Eugene T. Daum, former district sales engineer for Nordberg Manufacturing Co., has joined Conley-Lott-Nichols Machinery Co. as sales engineer.

W. L. DAVIS

K. ELLSWORTH

W. W. MEIN, JR.

N. J. REDMOND

H. J. ROBERTSON

M. E. COLSON

The Flintkote Co. recently announced the election of **W. L. Davis, Kennedy Ellsworth, Wm. Wallace Mein, Jr., Noel J. Redmond,** and **H. J. Robertson** as vice presidents. All are operating heads of Flintkote divisions. Messrs. Davis, Redmond, and Robertson are also Flintkote directors.

Max E. Colson was elected vice president of Atlas Powder Co. at a recent meeting of its board of directors. He will be in charge of the company's explosives division, succeeding **W. C. Lytle** who retired at the end of 1959. Mr. Colson has been with the explosives division, Wilmington, since 1952.

Two major executive appointments for the Marion Power Shovel Co., division of Universal Marion Corp., were recently announced. **Adrien F. Busick, Jr.,** formerly executive vice president and general manager, is now president and general manager of the division. The presidency has been vacant since the resignation of the late **Milton T. Smith** in July 1958. **David Reich** was appointed as-

sistant to the president of Universal Marion Corp. He retains his position of vice president administration of the division and in his new capacity will act as liaison officer between the division and Universal Marion Corp.

Edward Day Dickerman has been appointed senior metallurgist for the Western Div. of Vanadium Corp. of America. Mr. Dickerman was previously associated with the National Lead Co. at Monticello, Utah, as technical supervisor in uranium concentration.

Louis J. Czel recently joined the staff of American Potash & Chemical Corp.'s Land & Exploration Section as junior engineer. He recently completed his requirement for a masters degree in geology from UCLA. He was formerly with General Petroleum Corp. in northern Alaska as an exploration geologist and served for four years in the Navy Seabees on the Civil Engineering Staff as a surveyor.

R. M. McAlexander was recently promoted to mine foreman of the Last Chance No. 2 and the School Section Mine, Tallahassee Creek District, operated by the Gunnison Mining Co. Mr. McAlexander was formerly geologist at the Los Ochos Mine and then shift boss there.

Richard E. Dante, formerly mine engineer with International Nickel Co. of Canada Ltd., is now civil engineering assistant to the Monterey County Flood Control and Water Conservation District where he is engaged in a geologic and ground water study of the Salinas Valley area.

The Coronado Engineering Co., Palo Alto, Calif., was recently formed by **Richard H. Shaw** as sales representatives for manufacturers in mining, cements, and chemicals, covering 11 western states. Mr. Shaw had been sales engineer for Ingersoll-Rand Co. for 17 years.

Upon completion of the United Nations Korean Reconstruction Agency's mission at the end of 1959, with which he had served for four years, **Gunther Badorrek** returned to the U. S. to join the Crucible Steel Co. as junior industrial engineer.

B. H. Clemmons, USBM, has been transferred from the Southern Experiment Station, University (Tusculoosa), Ala., where he was station superintendent to the Metallurgy Research Center, Salt Lake City, where he will serve as research director.

Upon graduation from the University of Minnesota, **James W. Germundson** joined the Cerro de Pasco Corp. in Peru as assistant mine foreman.

Albert C. Walkup has joined the Green Mountain Uranium Corp. as mining engineer after a period with The Anaconda Co. as a trainee.

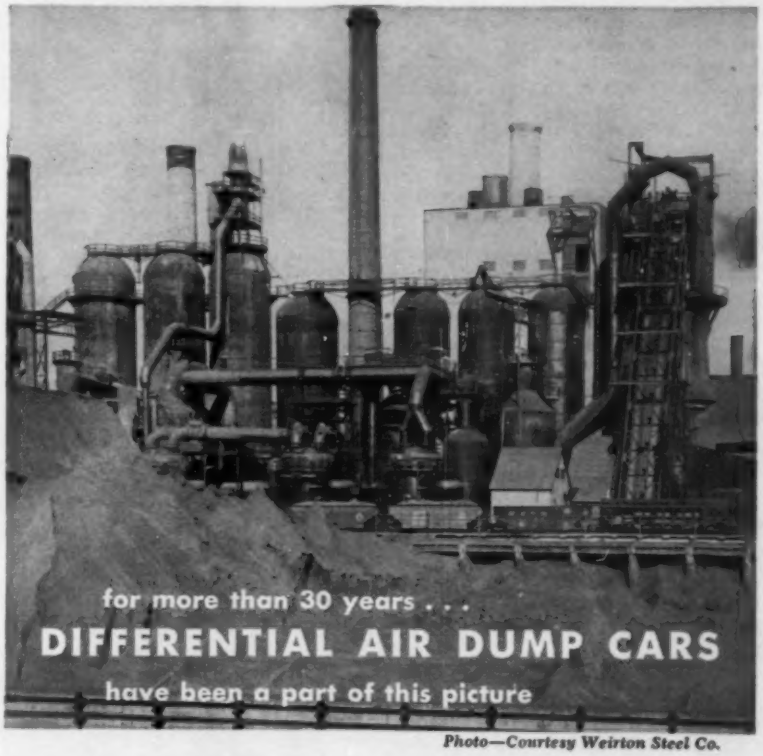
Peter Wallenberg has become managing director of Atlas Copco Rhodesia (Pvt.) Ltd., Salisbury, Southern Rhodesia. He had been manager of the Compressor Div., Atlas Copco Eastern Inc.

Fred Scharf has left York Mining Industries where he was an engineer to join Fenix & Scisson Inc. as project engineer.

Robert J. Stockton has joined the Federal Aviation Agency as a civil engineer after four years with the Smith-Douglass Co. Inc. where he had been a mining engineer.

The Emergency Lead-Zinc Committee recently announced that **Clark L. Wilson** of Salt Lake City has assumed the chairmanship of the Committee, succeeding **Miles P. Romney.** Mr. Wilson, vice president, New Park Mining Co., will devote his full time to this new post, taking up headquarters in Washington, D. C.

R. J. Councill has been appointed general industrial geologist for the Atlantic Coast Line Railroad Co. He was formerly industrial geologist for the company.



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SINCE 1915 PIONEERS IN HAULAGE EQUIPMENT

American Cyanamid Co. recently named **George L. Lyle, Jr.,** as chief engineer at the Brewster, Fla., plant. He succeeds **W. J. Pace** who retired Jan. 1, 1960, after 15 years with the firm. Mr. Lyle has been with American Cyanamid since October 1947. He has been assistant chief engineer since 1957.

Ben H. Parker, president of the Colorado School of Mines Board of Trustees has been elected president of the American Assn. of Petroleum Geologists. He will assume his duties after the 45th annual meeting of the association in Atlantic City, N. J., at the end of April. Dr. Parker is vice president and director of the Frontier Refining Co., Denver.

Maywood W. Chesson, Jr., has been named assistant manager of phosphate operations at American Cyanamid Co.'s Brewster, Fla., plant. He has been assistant to the manager of phosphate operations since February 1959. He has been with the company since 1947 when he started as process engineer.

S. Kyriakides joined the Inland Steel Co. as metallurgical trainee upon graduation from the Colorado School of Mines.

Alfred S. Harvey is working on the Atlas missile launch site connected with Forbes Air Force Base, Topeka, Kan., as plant construction engineer with Convair-Astronautics Div. of General Dynamics Corp. He was formerly sales engineer for Scott Material Handling Co.

Arthur W. Goring was recently appointed vice president and secretary of New Idria Mining & Chemical Co., Graham, Texas. He had previously been secretary-treasurer of the company.

James A. Pike has left the Newmont Mining Corp. of Canada Ltd. to become manager of the Dawn Mining Co. in Ford, Wash.

Paul C. Lyon, Jr., is no longer affiliated with Grand Deposit Mining Co. He is president of Western States Oil & Metals Co.; director of Allied Oil & Minerals Co.; and engineer for both companies.

Elza Fain Burch has become an assistant technologist at the U. S. Steel Research Center, Monroeville, Pa. He had been assistant director of preparation for the Island Creek Coal Co. in West Virginia.

Myron Read, formerly plant manager for Bestwell Gypsum Co., has gone to work for the Kaiser Gypsum Co., Albuquerque, N. M., whose nearby plant and quarry will be New Mexico's first gypsum works. Operations are expected to begin in May of this year. Mr. Read will be assistant plant superintendent and in charge of all quarry work.

Mine Safety Appliances Co., Pittsburgh announced three new assign-

R. S. JOYCE

T. J. O'NEILL

J. E. HOGAN

L. J. PATTERSON

ments in the International Div. recently. **Robert S. Joyce** was named manager, instrument sales; **T. J. O'Neill,** subsidiary services co-ordinator; and **John E. Hogan,** manager of the division's Latin American sales. Mr. Joyce joined the export sales group in 1947 as did Mr. O'Neill. Mr. Hogan came with the international group in 1957.

Quebec Cartier Mining Co., a U. S. Steel subsidiary, has announced the appointment of **Lewis J. Patterson** as vice president of operations. He will direct the operations of the new iron ore industrial complex which the company is developing in Saguenay county. Production is expected to start early in 1961. Prior to his appointment, Mr. Patterson had been associated with the Michigan Limestone Div. of U. S. Steel, his last post being manager of the Northern District since March 1957.

Helmut Leidhold has become assistant chief mine engineer for Frontino Gold Mines Ltd., San Juan, Argentina. He had formerly been a surveyor for the company.

Jachin M. Forbes has gone with The Beryllium Corp., Reading, Pa., as manager, minerals development, where he will direct activities related to exploration and ore beneficiation, with emphasis on improving the technology and economics of production from domestic low grade deposits. He had previously been assistant vice president of Wm. H. Muller & Co., New York.

Fred P. Battle has left the Kaiser Steel Corp., Fontana, Calif., where he served as metallurgist in the Tin Mill Div. to go with Union Carbide Ore Co., Newport News, Va., as plant metallurgist in the new manganese ore beneficiation plant.

J. S. Mitchell has taken a job as plant superintendent with Southwest Potash Corp., Carlsbad, N. M. He was formerly manager of research and process development for Nickel Processing Corp.

Manuel C. Caceres, Bolivian mining engineer, who completed graduate studies at the School of Mines of Columbia University, received his M. S. degree in mining engineering in February 1960.

Alex W. Laughlin, graduate assistant in teaching at the University of Arizona, received his M.S. in geology in January. He is awaiting orders to report for Navy Officers Candidate School, Newport, R. I.

The Potash Company of America recently announced the election of **John W. Hall** to the presidency of the company to fill the vacancy created by the resignation of **F. O. Davis.** Mr. Davis will remain available to the company on a consultation basis. Prior to his election as president, Mr. Hall served as vice president of sales and as a director of the company. **Dean R. Gidney** will succeed Mr. Hall as vice president of sales. The Company also announced the resignation of **Russell G. Haworth** as vice president in charge of production. He has served the company in a variety of capacities since joining them as a mine engineer in 1942. He will be succeeded by **Houston N. Clark** who has served as assistant to the president since Nov. 1, 1958.

Bernard J. O'Neill, Jr., has joined the staff of Stanford Research Inst. as geologist. Mr. O'Neill had been with The New Jersey Zinc Co. before joining the institute.

As part of its program for expanding its services to the mining industry, Stein Hall & Co. Inc., New York, recently announced the promotion of **Nathan A. Levine** to the newly created post of chief mineral engineer. In his new capacity, Dr. Levine will direct the work of Stein Hall's mining laboratory. At the same time it was announced that **Howard Dixson** had been appointed sales and technical representative to the mining industries in the Rocky Mountain area.

Vernon L. Mattson, manager of mineral development and research at Kerr-McGee Oil Industries' research laboratories in Golden, Colo., has been promoted to manager of mining and milling at the company's home office in Oklahoma City. He will be succeeded by **Wayne C. Hazen,** formerly research engineer at the Golden laboratories.

James S. Vanick, research metallurgist with the Development and Research Div. of the International Nickel Co. Inc., retired April 1, 1960 after 38 yrs of service. Mr. Vanick came to International Nickel in 1922 where he has concentrated upon foundry products in iron and non-

ferrous alloys. He is a past director of AIME and has held office in a number of foundrymen societies and other technical societies.

J. J. VANICK

W. H. DeHUFF

J. C. HUNTINGTON, JR.

J. E. LAFFEY

Harnischfeger Corp. is decentralizing its sales organization by dividing the United States into three major sales regions with a newly created sales manager position being established for each region. **William H. DeHuff** has been named manager for the western region with headquarters in San Francisco; **J. C. Huntington, Jr.**, manager for the central and southern region with headquarters in Milwaukee; and **J. E. Laffey,** manager of the eastern region with headquarters in Teterboro, N. J. All three men are veteran sales representatives of the company.

Obituaries

Gideon A. Apell

An Appreciation By
Harold B. Ewoldt

Gideon A. Apell was born Aug. 14, 1887, in Clintonville, Wis., and departed from this earth Apr. 27, 1959, from injuries received in an automobile accident near Holbrook, Ariz. The exact cause of the accident is unknown, but it appears that Gid was driving from their home in Sunland, Calif., to be with his wife, Leota, who was seriously ill at the home of her daughter in Pueblo, Colo. Gid lingered for about 10 days and the body was shipped to Pueblo for burial. Leota passed away late in May and was buried beside him.

Not too much is known of Gid's early life except a cryptic remark that he once made of having "worked in Chicago six years to earn money to complete my college education." He graduated from Michigan College of Mines at Houghton in 1915 and for the next two years was employed

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Alaska.....Contact Salt Lake City Office

in northern Michigan as an engineer for an exploration company prospecting for copper in the None Such Shales west and south of the present White Pine mine. In 1917 Gid joined the Army and served two years as Lieutenant in the Coast Artillery. After the war he was employed as an examination engineer and spent several years investigating bauxite deposits in Africa and South America, returning to Arizona where he operated a small mine near Prescott. Following this he returned to South America and as Gid so aptly expressed it "in 1932 we were thrown on the beach at Miami, Fla., with nothing but two trunkloads of winter clothes." Shortly thereafter he obtained a position with the Veterans Administration as an engineer and spent the next few years constructing hospitals. In 1940 he transfered to the U. S. Bureau of Mines and his first assignment was a manganese project near Aguila, Ariz. Gid continued with the Bureau until 1957 when he retired to a home in Sunland, Calif. His service with the Bureau covered many minerals and mining districts: tungsten in California; coal in Alaska; lead-zinc in Illinois, Wisconsin, and upper New York State; and staff work at the various regional offices. At the time of his retirement he was assigned to the Spokane, Wash., office.

Gid was a competent, dedicated, and sincere engineer, a warm friend with a contagious sense of humor. Many of us who worked with him in the field have fond memories of his ability as a raconteur, for after the day's work we would gather around the campfire or in his room at the boarding house to hear him relate some humorous episode. It can be truly stated that he was the salt of the earth.

Gid was a member of the Masonic order, the Elks, and the American Legion.

Ralph B. Utt

An Appreciation By
Harry N. How

One of the saddest events of 1959 was the passing July 21st, of Ralph B. Utt (member 1949), To those of us who were close to Ralph, his death was a blow whose force has dissipated little in the ensuing months. To the mining industry, his loss has left a gap in the already thin ranks of its true pioneers.

It is a gap which will be hard to fill, because for most of Ralph's 51 years he toiled tirelessly in the interests of the industry he loved so well. Only a short conversation with Ralph convinced you that here was no ordinary man, but one dedicated to a much higher goal than just meeting the challenges of everyday living.

There was a quiet intensity about Ralph, particularly in his speech, that was a reflection of his own dedication and integrity. Few who met him failed to come under its spell.

Born in Mansfield, Wash., he was reared near the Coeur d'Alene, Idaho, mining area, where he first developed his lifelong interest in mining. Ralph attended the Montana School of Mines, and received B.S. degrees in metallurgical engineering and mining engineering from the University of Idaho School of Mines. To carry part of the financial burden of his education, Ralph boxed professionally under the name of Young Firpo. His courage and skill in the ring made him one of the top light heavyweight fighters in the nation.

After graduation, his first job was as a mill operator for the Bunker Hill Mining Co. He quickly rose through the ranks to posts of increasing importance in the Bunker Hill Organization. Subsequently, he served as general superintendent for several mining operations in Montana and Oregon; and in 1936, he joined the Denver Equipment Co.

Walter B. Lenhart, long associated with mining in the West, clearly recalls Ralph's first sale. "I was superintendent of the Backbone mine, a gold mine in Shasta County in northern California. The mine was so far out of the way that no salesman had ever called on me before. Ralph, who was just a green kid then, traveled the eighteen miles of rutted dirt road to the mine with his usual determination. He went through the equipment he handled item by item. Each time I said 'No', his chin dropped a little lower, until finally he closed his notebook and started to leave. I figured, though, that anyone who would take the trouble to come all the way to that mine should get some kind of order. So I called Ralph back and gave him his first order—six barrels of Xanthate and some belt dressing."

In 1940, he joined Western Machinery Co. as a field engineer. He served both Western Machinery Co. and Western-Knapp Engineering Co. in a variety of capacities. He held the post of vice president and chief executive engineer at the time of his death.

During his association with Western Machinery Co., Ralph played a key role in the application of flotation and heavy media to improve process technology. His creative approach to equipment design resulted in the ultimate development of the Torque-Flow Pump, one of the most significant advances in pump design in many years—even though many of the so-called experts vowed its revolutionary new principle was unworkable.

Ralph took an active part in both local and national activities of the AIME, the American Mining Congress, and the National Sand and

Gravel Assn. In addition, he served The San Francisco Chamber of Commerce and the Commonwealth Club by participating in work on mineral industry problems. In 1957 he was one of the American delegates to the International Mineral Dressing Congress which met in Stockholm, Sweden.

In all his efforts, Ralph conscientiously applied his technical ability and practical know-how. However, he always maintained a sympathetic and understanding approach to the human aspects of his work. His genial disposition and consideration of others made him a friend to all who had the privilege of knowing him. No matter how pressed by the day's activities, he was always glad to share his experience and knowledge with others.

Throughout the many years of our association, Ralph and I attended many mining conventions throughout the country. I always enjoyed being with him at these affairs. They proved beneficial both in a personal and business way. We nearly always took our wives and attended banquets and other functions which made the whole thing very pleasant. I will miss Ralph most when these conventions come around again.

Bradley Stoughton

An Appreciation By
Allison Butts

Bradley Stoughton, (Legion of Honor Member 1897), died at his home in Bethlehem, Pa., on Dec. 30, 1959, at the age of 86. He had appeared to be in good health, going to his office at Lehigh University a part of every day when in Bethlehem. He passed away in sleep. During the preceding day he attended a meeting at the Lukens Steel Co. in Coatesville, of which he was a director. His associates and all who knew him marvelled at his unusual activity and vigor, which were scarcely diminished until the last year or two of his life.

Professor Stoughton was born in New York in 1873. He is survived by his wife, Merwin Roe Stoughton, by two sons and two daughters, five grandchildren, and two great-grandchildren.

He was one of the oldest and most distinguished members of AIME, having been a member for 62 years. He was secretary of the Institute from 1913 to 1921, chairman of the Iron and Steel Committee in 1922-1923, and was Howe Memorial Lecturer in 1927.

He was graduated from the Sheffield Scientific School of Yale University in the class of 1893 with the degree of Ph.D. He then went to Massachusetts Institute of Technology, receiving the degree of B.S. in 1896. Lehigh University awarded him the honorary degree of D.Eng. in 1943. He taught for a year at MIT after graduation and went to Columbia in 1897 as assistant to Henry Marion Howe. During the next four years he held successive positions with the Illinois Steel Co., American Steel & Wire Co., and Benjamin Atha & Co.

During his employment in the steel industry, he invented a side-blown converter for making steel castings and a process for oil melting in cupolas.

Returning to Columbia University in 1902, he taught for six years in the School of Mines and became acting head of the department of metallurgy. After a few years in business as a consulting engineer, he was elected secretary of AIME. In 1923 he went to Lehigh to head the department of metallurgy, retiring in 1939. From 1936 to 1939 he was Dean of Engineering at Lehigh.

Two World Wars and an event of outstanding economic importance in the steel industry commanded the service of Professor Stoughton. He was a member of the National Council of Defense, 1918 to 1919, head of the metallurgical division, and later vice chairman of the welding committee of the Emergency Fleet Corp. In 1922 he made a field study and wrote the report used by President Harding in the campaign to secure the eight hour day in the American steel industry. In 1941 to 1945 he was chief of the heat-treating equipment unit of the tools section, War Production Board, and was acting head of the foundry equipment section in 1944 to 1945. After the war he went to Europe as London representative of the Technical Industrial Intelligence Commission.

Service in professional engineering societies occupied a great deal of Bradley Stoughton's time. Nearly every one of which he became a member enlisted his talent for leadership in one way or another. He was president of the Yale Engineering Assn., 1922 to 1924. He was chairman of the Electrothermic Div. of the Electrochemical Soc. in 1922 and president of the Society in 1931. He was treasurer of ASM, 1938 to 1939 and president of the Society in 1941. He was president of the Engineer's Club of the Lehigh Valley, 1928 to 1929. He was a member also of AISI, the British Iron and Steel Inst., ASTM, CIM, the American Soc. for Engineering Education, Sigma Xi, and other societies.

He was awarded the Grasselli Medal by the Soc. of Chemical Industry in 1929. In 1943 the Lehigh Valley Chapter of ASM established in his honor the annual Bradley Stoughton Award for outstanding contribution to metallurgy.

Professor Stoughton was author of *The Metallurgy of Iron and Steel*, published in 1908, and for about 40 years the leading American textbook on the subject. In 1926 he was co-author of *Engineering Metallurgy*, a pioneer textbook in its field. In 1933 he was co-author of *The Alloys of Iron and Silicon*.

Professor Stoughton took an active part in civic and religious activities in Bethlehem. He helped to establish the Bethlehem Boy's Club. He was for a number of years superintendent of the Sunday School of the Episcopal Church of the Nativity, and in his later years was devoted to the Religious Soc. of Friends.

Bradley Stoughton

Memorial Resolution Prepared by *Allison Butts*

WHEREAS, with the death of Bradley Stoughton on December 30, 1959, the American Institute of Mining, Metallurgical, and Petroleum Engineers lost one of its eldest and most distinguished members, and

WHEREAS, Professor Stoughton was a member of the Institute for 62 years, was its Secretary from 1913 to 1921, and was Howe Memorial Lecturer in 1927, and

WHEREAS, he played a prominent part in the development of the iron and steel industry as author, inventor, educator, and consultant, and

WHEREAS, his services to the profession were manifold, signalled by election to the presidency of two of the leading national engineering societies and by important service to the national Government in several capacities, and

WHEREAS, his leadership in education was marked by his being Head of the Department of Metallurgy at Lehigh University from 1923 to 1939 and Dean of Engineering from 1936 to 1939,

THEREFORE, BE IT RESOLVED, that the American Institute of Mining, Metallurgical, and Petroleum Engineers records its sorrow over the passing of Bradley Stoughton, and

BE IT FURTHER RESOLVED, that this Resolution be spread upon the Minutes of this Meeting of the Board of Directors of the Institute and a copy be sent to Mrs. Stoughton.

February 14, 1960

It often happens that a feeling of high regard arises mutually between student and professor. With Bradley Stoughton it was much more than that. In many instances regard became a warm friendship which lasted through life. Keeping in touch with former students, and with a host of friends as well, took the place of a hobby for him. He had none of the frequent hobbies, but he did enjoy people, and his work was always a source of real pleasure to him. Perhaps most of all he enjoyed helping others. Possessed of a keen sense of humor, he was always ready with a story or joke. But these were reserved for sociability; he took his teaching and other work most seriously.

Alvin B. Carpenter

An Appreciation By
Wm. H. Crutchfield, Jr.

Mr. Alvin B. Carpenter, (Legion of Honor Member 1897), and well-known mining engineer and consultant, died in Hollywood, Calif., Dec. 10, 1959.

Born in Beloit, Wis., in December 1870, Mr. Carpenter graduated with a B.S. degree in chemistry and geology. After a year's graduate work at Beloit, he entered Michigan College of Mines, Houghton, Mich., in 1893 where he received his B.S. degree in mining engineering in 1896.

After a year's work in the United States, Mr. Carpenter went to Mexico. In three years he was made manager of the Carmine, Mexico, Mines in El Oro, and the Borda. Following the successful management of these properties, he became very active as a mining consultant in Mexico until the early days of the Revolution. Returning to Los Angeles in 1911, he enjoyed a successful consulting practice until his retirement in recent years.

Always an ardent alumnus of both Michigan College of Mines and Beloit College, Mr. Carpenter received the Distinguished Service Citation from the latter college in June 1953. At Beloit he was a member of Phi Kappa Psi fraternity and earned membership in Tau Beta Pi while at Michigan College of Mines.

The engineering profession in Los Angeles benefited from his participation as member of the Los Angeles Engineering Council and the Mining Committee of the Chamber of Commerce.

Although the writer knew Mr. Carpenter only during the latter years of his life, this period of time was more than sufficient to appreciate that he was not only a competent mining engineer but also a gentleman in every sense of the word.

He was a successful product of an early era of mining—an era of technical hardship, so to speak. One, that by its very nature of transition, posed critical demands for basic advance in mineral technology. The successful meeting of these demands produced a singular breed of all-around mining man. One of these was Alvin B. Carpenter.

Melvin Porterfield (Member 1951) died in July 1957. He had been born in Silver City, N. M,. and attended New Mexico Agricultural and Mining College. He worked in sales and clerical work from 1936 to 1941, then became electronic technician in the U. S. Navy. He was vice president and general manager of E. Cosgrove Inc. in Silver City.

David H. Wilson (Member 1955), born in Indiana in 1895, died Mar. 10, 1959. He had attended Stanford University and the University of Oregon, receiving a B.S. in 1918. He was inspector for Arthur Iron Mining Co. for ten years, then joined Nelson Mining Co. For two years he did aerial mapping of Superior National Forest as party chief, then returned to Arthur Iron Mining Co. as chief inspector, living in Marble, Minn.

Ben B. Chomiak (Member 1948) died in 1958 at the age of 35. He was born in Palmer, Pa., and graduated from the Colorado School of Mines in 1951 with an E.M. degree. He was a pilot doing aerial crop dusting for Inland Aviation Corp., and worked for the Research Foundation Inc. of the Colorado School of Mines. He worked for the Colorado Fuel & Iron Corp. and American Smelting & Refining Co. in Mexico. In 1953 he was mine foreman for Cia. Minera Asarco, then went to South West Africa for Tsumeb Corp. Ltd. He returned to Mexico in 1956.

John W. Sheedy (Member 1943) died Jan. 16, 1959, and was buried in his home state of Montana. He had graduated from Montana School of Mines, University of Montana, in 1915 with an E.M. degree and began work in the research laboratory of Butte and Superior Mining Co. In 1920 he joined Iron Cap Copper Co., then became general mill foreman for Nevada Consolidated Copper Corp., remaining in that position 14 years. He was mill superintendent for Cia Huanchaca de Bolivia in 1936 and senior engineer for Metals Reserve Co. in 1943.

Tom Lyon (Member 1925) died in in San Diego on July 31, 1959. He was consultant to the Southwestern engineering Co. of Los Angeles. From 1922 to 1950 he was chief geologist and later assistant general manager of the International Smelting and Refining Co., division of The Anaconda Co. In 1953 he was nominated by President Eisenhower as director of the U. S. Bureau of Mines, but withdrew his name. He had served as chief of the copper branch of the U. S. Defense Minerals Administration. He was a graduate of the Montana School of Mines and lived for many years in Salt Lake City.

William J. Owen (Member 1955) was killed in a private plane accident in August 1959. Born in Shreveport, La., he was a resident of Moab, Utah, and Denver, where he was president of Triton Oil Co. He graduated from the University of Texas and did graduate work on a teaching fellowship. He gained exploration experience with Hunt Oil Co. in Dallas and was an independent consulting geologist in Moab.

W. E. Porter (Member 1913) has passed away. He was born in Cimarron, N.M. in 1879 and attended Sheffield Scientific School, Yale University, before beginning mining at Silverton. Colo. and producing oil in Wyoming.

Guy C. Riddell (Member 1913), retired associate member of Senior Consultants Inc. in New York, died July 19, 1959 in Easton, Md. He graduated from Massachusetts Inst. of Technology with a B.S. degree and became superintendent of a lead smelting plant in Butte, Mont. for the American Smelting and Refining Co. Mr. Riddell served as consultant to the U. S. Tariff Commission, and later as consultant to the Russian Government on the creation of their helium industry, while surveying Russian potash, sulphur, nickel, and petroleum industries for American corporations. He was also advisor to our military government in Korea.

Girard B. Rosenblatt (Member 1914) died on July 15, 1959. He was born in New York and educated at Columbia University School of Mines receiving an E.E. degree in 1902. He gained experience in New York and Pittsburgh before being named engineer in charge of the Butte office for Westinghouse Electric & Manufacturing Co. In 1928 he became Pacific Coast industrial manager for the firm with headquarters in San Francisco, where he worked for many years, later becoming vice president of Fischbach & Moore.

Arthur F. Taggart (Member 1914), noted engineering author and professor, died on Aug. 22, 1959 in White Plains, N. Y. Born in New York, he attended Stanford University and earned an M.E. degree there, and was awarded a doctorate from Columbia University where he was a professor emeritus. He was instrumental in developing the flotation process of mineral separation and his book *Handbook of Ore Dressing* remains the standard reference work in that field. He conducted geological exploration in Bolivia and was a mining instructor at Yale University before joining the staff at Columbia.

William E. Wainwright (Legion of Honor Member 1903) passed away

on May 3, 1959. He was born in London and educated at Soulaine University School of Mines. He was mill manager of Ivanhoe mine in Kalgoorlie and Broken Hill South Ltd. in Australia, spending many years as consulting engineer for the latter firm in Melbourne.

Frederick R. Weekes (Legion of Honor Member 1907) died Sept 2, 1959 in New York. He had been born in New Jersey and educated at Columbia University School of Mines. He spent several years gaining experience in mining interests in California, Mexico, and Florida before joining A. Chester Beatty. He was a consulting engineer with offices in Vancouver, B.C. and San Francisco and was manager of the Porcupine Gold Fields Development Company Ltd. and Ventures Ltd. Mr. Weekes was a pioneer in aerial surveying of geological formations for mining purposes.

William B. Wood (Member 1956) died in Bogota, Columbia, on Aug. 6, 1959, where he was employed as research metallurgist by Colomar Inc. A native of Spokane, he attended the Mackay School of Mines, University of Nevada and had a variety of jobs with firms such as U.S. Gypsum Co. and Consolidated Coppermine in Kimberly, Nev. He had been raised in the mine camps of Idaho, beginning his first job at the age of 12. He also worked for The Anaconda Co. and spent several years in independent consulting work.

Arthur Chippendale (Legion of Honor Member 1899) died Nov. 21, 1959, in Temple, Texas, after a long illness. Born in 1867 at New Castle on Tyne, England, Mr. Chippendale came to this country in 1900. His career as a mining engineer subsequently took him to Mexico and South Africa.

R. C. Dempster (Member 1949), 68, retired mining engineer, died Oct. 24, 1959, in Portland, Ore. Prior to his retirement, Mr. Dempster had been co-partner and general manager of Canusco Inc. He was born in Nanaimo, B. C., Canada, and was educated at Trinity College School and McGill University.

R. T. Elstad, (Member 1938) 64, president of U.S. Steel's vast Oliver Mining Div. in northern Minnesota for 13 years died Dec. 14, 1959, after a long illness. He joined the Oliver Div. upon graduation from the University of Minnesota 40 years ago. His first job was as mining engineer in the Canisteo district. He joined the main office in Duluth in 1938 as an assistant to the vice president and general manager and became president in 1946. He was a native of Independence, Wis.

J. S. Godard (Member 1939) died July 22, 1959. Mr. Godard was born Aug. 22, 1894, in Ottawa and was educated at Queen's University, and McGill University. He had been chief metallurgical engineer for Canadian Industries Ltd. at the time he applied for membership in AIME.

Edward S. Grant (Member 1952) died Oct. 19, 1959, at Bingham, Utah, where he had spent his entire life. He was born there in 1909, attended Bingham high school, and worked in the area for Kennecott Copper Corp. during his entire professional career.

John C. Haddock, Jr. (Member 1922), president of the Morris Run Coal Co., died Nov. 10, 1959. He formerly headed the Haddock Mining Co., the Silver Brook Anthracite Co., and the Alden Coal Co. Mr. Haddock was born Nov. 24, 1893, in New York. He was educated at the Taft School and Yale.

G. V. Hobson (Member 1921) died

(Continued to page 412)

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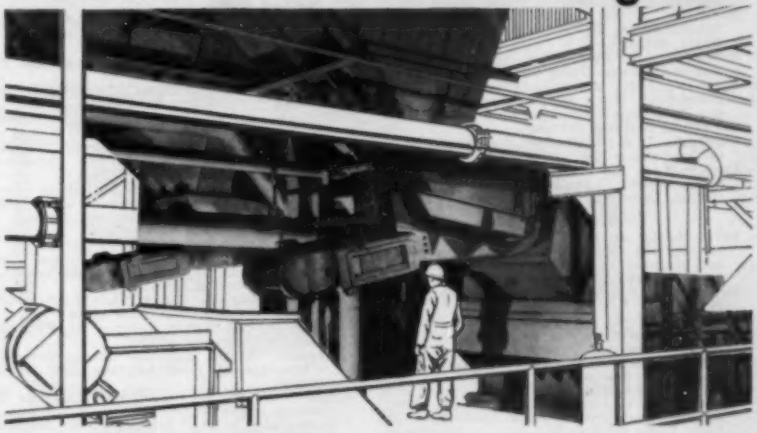

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NOTICE—SME PREPRINT AVAILABILITY, 1960 ANNUAL MEETING

The following list of papers (from the 1960 New York Annual Meeting) will be available until Jan. 1, 1961. Coupons received with the 1960 dues bills and those distributed at the 1960 Annual Meeting will also expire on this date. Purchased coupons books will be honored on any future date. A new listing of available papers will appear in a forthcoming issue. It will include additional papers presented at the 1960 Annual Meeting (New York) and at other SME meetings throughout the year. **Preprints may be obtained (upon presentation of properly filled out coupon) from SME Headquarters, 29 W. 39th St., New York 18, N. Y.** Coupon books may be obtained from SME for $5 a book (10 coupons) for members or $10 a book for nonmembers. Each coupon entitles the purchaser to one preprint.

Coal (F)

Coe, G. D., and Keller, G. E.: *Tube Furnace Method for Rapid Determination of Sulfur in Coal.* **60F40**

Corriveau, M. P., and Coll, H. F.: *Solving the Flocculation Problem.* **60F59**

Davis, D. H.: *Mechanized Tamping of Mine Haulage Roads.* **60F80**

Ellison, L. D.:*Efficient Pillar Extraction by Means of Exhaust Ventilation.* **60F32**

Kamper, O. W.: *The Exploration and Mining of Raw Materials-Production of Refractory Products-Application for the Utilization of Coal.* **60F30**

Lucas, J. R.: *A Field Study in Acid Mine Drainage.* **60F35**

Mason, J.: *Daily Maintenance and Complete Overhaul of Continuous Miners.* **60F65**

Morris, F. M.: *Moss Number 3 Mine: The Materials Handling Aspect.* **60F44**

Osmanski, J. E.: *The Communications Challenge of Automation.* **60F104.**

Poundstone, W. N.: *Face Ventilation in Development with Continuous Miners.* **60F32**

Rao, P. D., Charmbury, H. B., and Mitchell, D. R.: *Crushing of Anthracite for the Reduction of Domestic to Steam Sizes.* **60F74**

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Stachura, J. A.: *Selecting the Proper Type of Continuous Miner.* **60F49**

Updegraff, L. A.: *Continuous and Automatic Measurement of Moisture in Coal by Capacitance.* **60F21**

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James Irvine

(Continued from page 396)

the 1960's, rather than the industry-by-industry approach used in many safety conferences.

Two years ago Irvine addressed the Conference as a representative of the Boy Scouts. He expects to apply his interest in occupational safety upon graduation.

James C. Irvine proudly displays the invitation he received from the White House to attend the President's Conference on Occupational Safety.

ASCE Forms Engineering Visitors' Group in NY

Foreign engineers who wish to see the civil engineering projects for which New York is world famous will find their paths smoothed by the newly organized Engineering Visitors' Committee of the Metropolitan Section of ASCE, the section's president, Michael N. Salgo, announced recently.

The committee was formed as a result of a survey which disclosed foreign engineers on tour through the United States have regretted their inability to see anything more than the Empire State Building or the United Nations on stopovers in New York. The committee will remedy this by acting as a central referral service to arrange trips to local projects. Its services are available without charge as a professional courtesy to fellow engineers.

Among the sights exepected to interest the visitors—which local residents take for granted—are: the docking of luxury liners in the heart of a great city, the rapid movement of vehicular traffic on a radial highway system, the Port Authority bus terminal, the skyscrapers along Park Avenue built atop a railroad, the complex approaches to the Lincoln Tunnel. In addition, the city is dotted with major construction works in their early stages. Noteworthy are the addition of a second level to the George Washington Bridge, Lincoln Center for the Performing Arts, numerous tall office buildings; low cost housing, the Bruckner Boulevard expressway.

Through the new committee's chairman, A. Edward Dembitz, arrangements can be made to inspect these and many other types of projects. The lengthy list includes waterfront facilities, concrete plants, subways, waste treatment plants, tunnels, complex foundation work, and airports.

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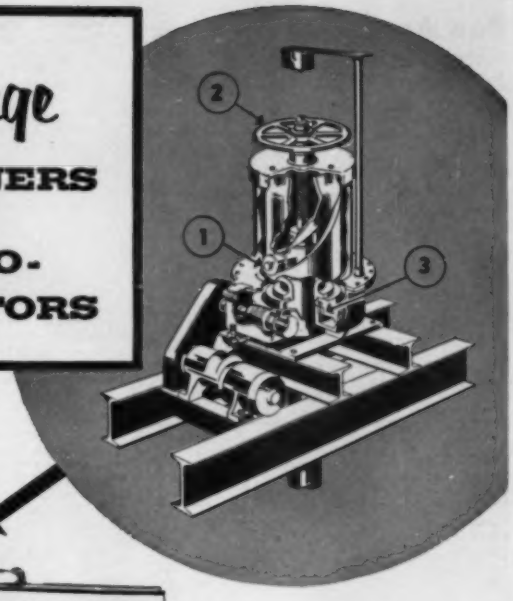

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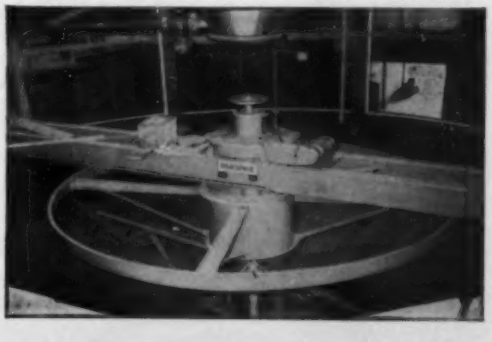

A 35'-diameter Hardinge Superposed Thickener installation in a Canadian lead-zinc concentrator. The sludge outlet for the upper unit can be seen at the top of the picture. Note froth ring on lower unit.

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Pan American Congress

The Pan American Congress on Engineering Education (September 12 to 16) and the Seventh Convention of the Pan American Assoc. of Engineering Soco. (September 19 to 23) will meet in Buenos Aires this year according to an announcement from Gail A. Hathaway, chairman, Committee on International Relations, Engineers Joint Council. These meetings will provide opportunities for engineers throughout the Hemisphere to get together in technical and business sessions and contribute to the further development of the profession.

Necrology

Date Elected	Name	Date of Death	
1930	Axel E. Anderson	Jan.	10, 1960
1954	Robert F. Brown	Jan.	11, 1960
1897	Alvin B. Carpenter (Legion of Honor)	Jan.	10, 1960
1917	S. N. Castle	Feb.	10, 1959
1937	J. B. Christie	July	15, 1959
1937	George L. Clemens	Nov.	17, 1959
1954	Douglas E. Daffin	Nov.	16, 1959
1949	E. G. Lewis	June	18, 1959
1936	G. C. Lipsey	Jan.	14, 1960
1935	Homer A. Mann	Jan.	13, 1960
1947	Ray Meade	Unknown	
1939	Joseph A. Mecia	Jan.	13, 1960
1932	Jared H. Miller	Jan.	16, 1960
1957	Charles D. Nevels	Nov.	16, 1959
1955	F. W. Parrott	Dec.	30, 1959
1954	H. D. Pinkney	Jan.	19, 1960
1954	Kenneth G. Redman	Oct.	23, 1959
1949	F. C. Sammons	Jan.	17, 1960
1941	J. G. Tate	Oct.	23, 1959

Membership

Proposed for Membership

Society of Mining Engineers of AIME
Total AIME membership on Feb. 29, 1960, was 33,747; in addition 2,511 Student Members were enrolled.

ADMISSIONS COMMITTEE
S. S. Cole, Chairman; F. A. Ayer, Vice Chairman; F. Wm. Bloecher, Jr.; Jack B. Graham; C. H. Lambur; Pauline Moyd; R. H. Ramsey; A. D. Rood; W. J. Rude.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's owce if names of people are found who are known to be unqualified for AIME membership.

Members

Charles H. Andrewson, San Francisco
Henry J. Bente, Bethel Park, Pa.
Hamilton P. Brown, Hoyt Lakes, Minn.
Patrick J. Casella, Old Forge, Pa.
John G. Cazort, Jr., Pittsburgh
John Chupeck, Simpson, Pa.
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Obituaries

(Continued from page 409)

Mar. 16, 1959 in London, England. Dr. Hobson spent a large part of his professional career in India, as a geologist and teacher. He was born in Droitwich, England, in 1893 and received his degree from the Royal School of Mines, London, in 1920.

H. E. Jackman (Legion of Honor Member 1909), president and cofounder of the Syndicate Oil Corp., died Oct. 29, 1959, after a short illness. Mr. Jackman was born in Rochester, N. Y., in 1881. He was a graduate of Syracuse University and Michigan College of Mines. In 1918 he established his corporation with several other Rochester men. It has oil wells in Oklahoma, Texas, and Kansas.

Chet A. Kershaw (Member 1956) died July 18, 1959, in Portland, Ore., where he had his own business as a consulting and design engineer. Mr. Kershaw was born Oct. 18, 1914, in Westhope, N. D. He attended the College of Engineering, University of Minnesota, 1932 to 1934.

Clement H. Mace (Member 1937) died Apr. 5, 1959, in Denver, Colo. Mr. Mace was born in Dunlap, Iowa, in 1882. He received his B.S. in mining from the University of California in 1906. After working in the field for a number of years, he formed his own company in 1923 acting as president and general manager.

Thomas F. McGivney (Member 1946), who was born in Howell, Mich., Dec. 15, 1887, died at Carlsbad, N. M., where he had worked as an engineer for more than a quarter of a century. Mr. McGivney was a graduate of the University of Michigan. He began his professional career in El Paso in 1913 and, except for a brief period in Newfoundland, pursued his career in the Southwest until his death.

Wm. M. Morgan (Member 1937), 69, director, Cia Del Monte y Pachuca, died Oct 7, 1959, in Pachuca, Mexico. He had been employed by various mining companies in Mexico over the last 40 years. Mr. Morgan was born in Durham, Wash., in 1890, and graduated from Queen's University, Ontario in 1915. He began his professional career in 1916 as mine foreman at Morococha, Peru. In 1920 he came to Mexico where he was to spend the rest of his life.

B. P. Mulcahy (Member 1954), president of Fuel Research Laboratory Inc., died on Aug. 31, 1959. Born on Aug. 23, 1899, in Geneva, N. Y., he was educated at Hobart College and the University of Illinois from which he received his degree in chemical engineering in 1925. Upon graduation he went to work as a chemical engineer for Associated Gas & Electric Co., Geneva, N. Y. He moved to Indiana in 1928 when he became chief chemist for Indiana Gas & Chemical Corp., Terre Haute. In 1936 he moved to Indianapolis, where he was living at the time of his death.

James C. Neal (Student Member 1955) drowned while skin diving in the Gulf of Mexico near Panama City, Fla., Aug. 15, 1959. A native of Superior, Wis., where he was born June 15, 1933, Mr. Neal had at-

tended Grinnell College for a year, then entered the Colorado School of Mines.

Robert R. Schultz (Member 1936), who has been associated for 25 years with the crushing, mining, and road machinery industries, died Dec. 6, 1959, at his home in Joplin, Mo. Mr. Schultz was a native of Mount Vernon, Ind. After graduating from the Colorado School of Mines in 1936, he worked for Traylor Engineering & Manufacturing Co. of Allentown, Pa. During World War II he served with the Corps of Engineers. For the past nine years he was executive vice president and general manager of the Rogers Iron Works Co.

P. S. Stevens (Member 1956) of Lakeland, Fla., died Oct. 26, 1959. Mr. Stevens had been retired since December 1954 after 38 yrs. with Bucyrus-Erie Co., So. Milwaukee, Wis. He had been vice president in charge of engineering at the time of his retirement. Born Oct. 28 1889, in St. Louis, he received his degree in electrical engineering from Washington University there in 1913. He went to work for General Electric in Schenectady upon graduation, then returned to St. Louis the following year where he remained until joining Bucyrus-Erie in 1916.

Thornburg W. Grath (Member 1959) was killed in a hunting accident Oct. 18, 1959. Dr. Thornburg, a dentist, was part owner and president of Lakeview Mining Co., Lakeview, Ore., engaged in exploration, development, and mining of uranium and in construction and operation of a 300-tpd uranium mill. Dr. Thornburg was born May 13, 1919, in Concordia, Kan., and was a graduate of the University of Kansas City Dental College. In 1950 he began his career in mineral exploration and mining and in the course of it developed three successful mines from prospect stage to important ore bodies.

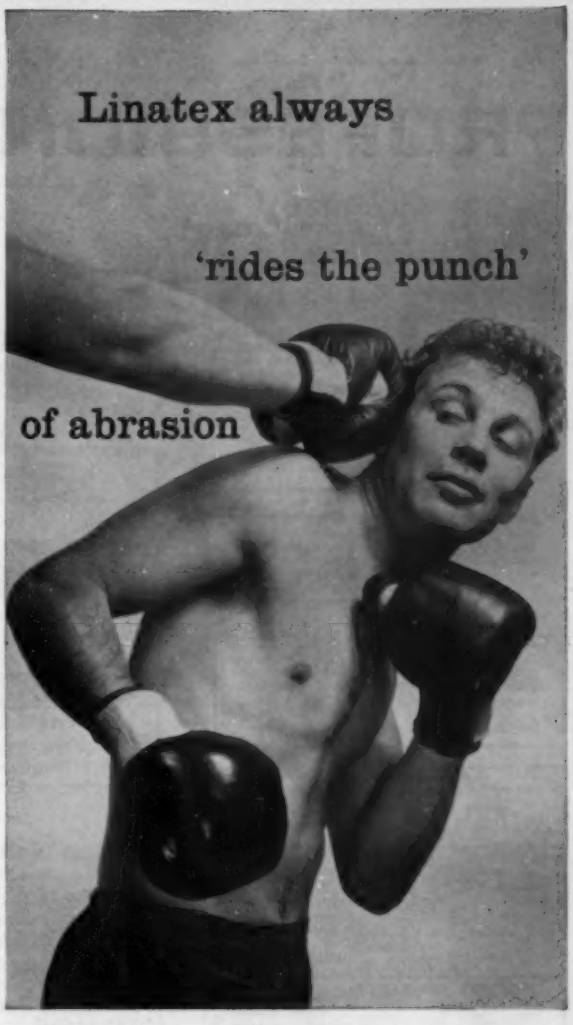
Edgar C. Weichel (Member 1923), died at Concord, N. C., Aug. 14, 1959, after a long illness. Mr. Weichel was a native of Scranton, Pa., and had been associated with the Hudson Coal Co. there for 32 years before his retirement in 1955. He had been vice president of the firm from 1950 to 1955. He began his mining career in 1903 with the Hillside Coal & Iron Co.

Roy D. McLellan (Member 1936) died on Jan. 27, 1960 at the age of 67. Dr. McLellan, until his retirement in 1957 after 37 years with the American Smelting & Refining Co., was in charge of petrography at their Central Research Laboratory, Plainfield, N. J.

Samuel B. Kanowitz (Member 1928) died Dec. 29, 1959, in the Indian River Memorial Hospital, Vero Beach, Fla., after a long illness. Mr. Kanowitz was with Raymond Pulverizing Div. of Combustion Engineering Corp. for over 40 years and was an authority on the pulverizing of chemical materials. He was manager of Raymond's New York office for 35 years before retiring in 1955. Mr. Kanowitz was born in Greensburg, Pa., and was a graduate of Cornell University.

Holland R. Wemple, retired vice president and director of Texas Gulf Sulphur Co., died Dec. 27, 1959, in St. John's Hospital, Springfield, Ill. He was on a visit from New York to his home town of Waverly, Ill., when he was taken ill.

L. A. Tillotson (Member 1946) died Dec. 27, 1959, in a Carlsbad, N. M., hospital following an extended illness. Mr. Tillotson was born Oct. 23, 1911, at Rosewell, N. M., where he attended public school and the New Mexico Military Institute. He received his B.A. and B.S. degrees in chemical engineering from the University of Colorado. Upon graduation in 1933 he joined the United States Potash Co. as a chemist, becoming chief chemist in 1947. Since July 1958, he had been refinery superintendent of the company, now United States Borax and Chemical Corp.



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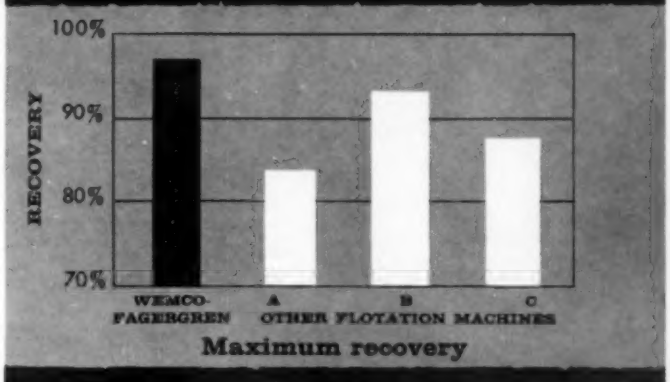

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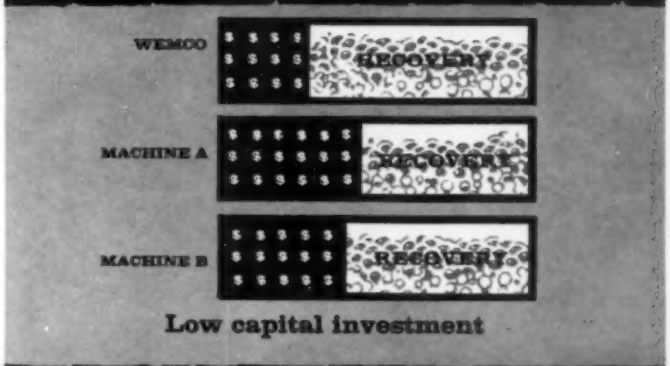

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